UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1944

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Washington, D. C. January 1945

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AIDING THE WAR EFFORT THROUGH EXPERIMENT STATION RESEARCH

The reports of the past 2 years have told how the State experiment stations responded to the need for information to aid food production in the emergency. Again, in 1944 these research agencies played an important part in the unparalleled war production of American agriculture.

Throughout the war period the experiment stations have continually reviewed and redirected their research work in line with the changing needs of the war food program. Greatly expanded demands for food, fibers, oils, and other strategic farm products have brought new problems of production to the stations for solution. Problems of transporting products and supplies, of best ways of processing and storing, of substitution for critical materials in short supply, and of helping to alleviate farm-labor shortages have demanded and received at-

[1] Submitted in accordance with the requirement that the Secretary of Agriculture shall report to Congress on the work and expenditures of the State agricultural experiment stations established under the Hatch Act of 1887 and supplementary legislation. The period covered is the fiscal year ended June 30, 1944.

tention. National consciousness of the importance of adequate nutrition for civilians and the armed forces has called for new facts on nutritive requirements and nutritive values of foods.

In meeting these demands the stations have focused their research on the most urgent problems of the States and localities within the framework of national programs and requirements. Significant facts on many new problems have been sought and obtained in the least possible time commensurate with sound results. These new facts have been blended with the cumulative findings and practices of a half century of agricultural science to form a body of information which farmers have applied in producing the greatest volume of food in the history of the Nation. Except for the timely aid of research facts, production might have fallen far short of needed goals.

Many specific examples of timely aids within the year are cited in this report under the sections relating to food, feed, and fiber crops, animal products, better nutrition, and economic and social adjustments. These examples were selected from a much larger number of contributions to illustrate the scope and significance of the findings and their application. Many other important items could be cited.

Adjustment of research projects.—Research by the agricultural experiment stations under the Federal-grant funds is organized by projects, whereby the problem, objective, and plan of work for each specific study are outlined as a working guide before the study is undertaken. These projects are cleared through the Office of Experiment Stations for suggestions and approval, and programs covering allotments of grant funds by projects are reviewed and approved annually. In meeting the changing needs of the war situation, the stations in 1944 adjusted their research programs by undertaking work on 641 new and revised projects under the grant funds. In all, 3,484 Federal-grant projects were active during the year. Many of the 2,843 projects continued from 1943 had yielded information that had been released for immediate use, but additional study was needed on other phases of the problems.

Many of the Federal-grant fund projects are supported in part by allotments of State funds, which are used to supplement the Federal funds for various types of expenditures. In addition, much of the over-all support for Federal-grant projects is provided by the States. The experiment stations also conduct research and experimental work supported entirely by funds of State origin. In 1944 this work was organized under 4,778 projects.

Station-Department teamwork.—Within recent years a noteworthy measure of cooperation in research has been in effect among the stations and between stations and the Department. The wide diversity of the agriculture of the States, Territories, and Puerto Rico quite naturally leads to much localization in the problems requiring investigation. Many of these problems, however, cross State boundaries and are the mutual concern of groups of States and of research bureaus of the Agricultural Research Administration and other agencies of the Department which deal especially with regional and national problems. Opportunity for effective teamwork is provided by this type of problem, and a great deal of beneficial cooperation results. In some cases cooperation involves formal agreements or memoranda of understanding, but much is accomplished through informal exchange of information and materials.

Formal cooperation between the stations and agencies of the Department in 1944 was carried on under approximately 1,190 memoranda of understanding involving more than 1,030 separate research undertakings. Typical examples of large-scale cooperative undertakings of national scope are illustrated by research on various aspects of soil-erosion control effective between 48 stations and the Soil Conservation Service; on breeding, culture, and diseases of potatoes between 28 stations and the Bureau of Plant Industry, Soils, and Agricultural Engineering; and on cereal crops and diseases between 25 stations and the latter Bureau. All of the State stations have participated with the Bureau of Agricultural Economics and the Agricultural Research Administration in assembling data for estimates of maximum production capacity as a basis for 1945 production goals and other national programs.

The cooperation of the Department is acknowledged in a number of the examples of station contributions later in this report. There are probably other cases of cooperation in some form that have not been cited but may be covered in a general acknowledgment of the helpful teamwork of agricultural scientists throughout the State and Federal services.

Cooperative research in nutrition.—The national project on conservation of the nutritive values of foods, undertaken upon recommendation of the Committee on Foods and Nutrition of the National Research Council, is organized on a national scale by regions, with the Office of Experiment Stations participating in over-all assistance and coordination. Experiment stations in 44 States cooperated during 1944 in securing information on about 65 different foods. This information is of immediate service to those responsible for the food supply of our armed forces and of value to agriculture in meeting increasing interest and demand for high nutritive quality in foods. A more complete statement of accomplishments is given later in this report.

Twenty stations and the Department continued cooperation in a study to determine the extent to which butter in the usual trade channels can be depended upon to furnish a uniform supply of vitamin A and in what amount. As in the case of the above study, this joint effort was undertaken upon recommendation of the Committee on Food and Nutrition of the National Research Council. The Office of Experiment Stations assists in coordination.

The cooperative vegetable-seed treatments.—This activity, carried on during the year by 60 workers in 34 States and 2 Canadian Provinces under a committee of the American Phytopathological Society, is another example of effective large-scale teamwork in research noted in more detail later in this report. Sixteen different chemical compounds were tested as seed disinfectants or protectants on 1 or more of 13 different vegetable crops. The Department participated and made possible the publication of a mimeographed summary of results. New information from these studies has resulted in marked expansion and greater efficiency in the treatment of vegetable seeds by growers, with consequent improvement in stands and yields due to reduction in disease losses. Another result has been the initiation of a movement toward the pretreatment of vegetable seeds before they are sold. Five large seed firms are now treating some vegetable seeds in in this way.

PRODUCING NEEDED FOOD, FEED, AND FIBER CROPS

In supporting the efforts of farmers to produce needed crops and supplies of plant products the experiment stations have contributed research information on the selection and management of soils for the production of particular crops and use of fertilizers for maximum efficiency. Better varieties of crop plants have been developed to meet widely diverse growing conditions and particular requirements for special uses. New and better ways of growing, harvesting, and storing crops have been sought and found. New light has been shed on diseases and pests and ways of combating them.

BOOSTING SOIL PRODUCTIVITY

Station research to increase crop production through soil-management practices in 1944 was directed mainly toward the application of new facts about soils and the extension of previously established findings to promote maximum efficiency and minimum loss of soil fertility in carrying the heavy wartime load. In the investigation of practices for highest production, the evaluation of soil-management systems aimed at the restoration of fertility expended for wartime production and the maintenance of the restored fertility for possible future periods of urgent need warrants special attention. Building a reserve of potential crop production through increased soil fertility is an important consideration for future national security.

There are many instances where meeting a particular production goal in a State or area was aided materially by the application of findings from the experiment stations showing how soil-management practices affect production or which soils are best adapted to the production of certain crops. During the present period of great demand, emphasis is placed on practices that show promise of resulting in immediate increases in production. Facts for the formulation of these practices of immediate production significance originate principally from long-time field and laboratory investigations of the properties and behavior of soils under different conditions and treatments. The nature of some of these studies and their application and effect on production are discussed in the following brief review.

EFFECT OF PREVIOUS SOIL MANAGEMENT ON PRODUCTION

Crop rotations and diversified farming.—These have long been recognized as basic to a permanent agriculture. The need for, and wisdom of, the good soil management involved in these practices become more real under war conditions when there is a premium for extra production. For example, 50 years of field-plot work by the Missouri station, with different rotations and soil treatments, have shown that rotation, whether long or short, result in higher yields and greater net returns than continuous culture. Using the amount of loss of soil nitrogen as the index of soil-fertility decline, the station found that crop rotations alone, without the necessary fertility additions such as farm manure, lime, and commercial fertilizer, could not indefinitely maintain profitable yields of high-quality crops.

Soil upkeep in wartime farming.—Stressing the demands on soil fertility and organic matter for meeting wartime food production, the Minnesota station has shown that after 60 years of cultivation the

total organic matter of Minnesota soils has been reduced about 42 percent. Further decreases will limit production, and the station prescribes a definite system of soil management, including crop rotation, use of manure and crop residues, use of commercial fertilizers, use of lime, improved cultural practices, and use of erosion-control practices.

Crop rotation and soil-management practices.—Crop rotation and soil management were found effective in bringing back to profitable production badly eroded soils in the upland areas of Arkansas, according to results of cooperative studies by the Arkansas station and the Soil Conservation Service. The average yield of seed cotton from a practical system of rotation including fertilizer was increased after a 4-year period from 613 to 1,154 pounds per acre.

Grape yields.—Reduced yields in the Ohio grape-producing area were found from laboratory soil studies by the Ohio station to be the result of soil-management practices that caused depletion of soil nitrogen, organic matter, and a lower total nutrient supply. The loss of organic matter not only resulted in decreased fertility but contributed to a condition in the soil where the amount and movement of air is insufficient to permit the plant to absorb and use the nutrients of the soil for growth. The use of cover crops and mulching materials is restoring the productivity of the soil.

Previously grown crops.—Rhode Island station studies to determine the best place for a particular crop in the rotation showed that onions were the best crop preceding onions, while timothy and beets had an intermediate effect on the yield of onions. On a relatively acid soil, red clover was detrimental to the onion crop following, because of the greater removal of soil bases.

Soil-fertility factors affecting soybean yield.—High yields of soybeans can be obtained only on fertile soil; they definitely are not a poor-land crop. Although soybeans do not respond so well as alfalfa or corn to direct applications of phosphorus and potash, experiments of the Iowa, Illinois, Missouri, and other Midwest stations show that they return higher yields with good soil-management practices. Use of lime and fertilizers in the rotation where needed, contouring on rolling soils, and especially use of manure contribute to high acre yields.

Soil organic matter affects potato yields.—Soil-management practices under irrigated agriculture were found by the Montana station to be an efficient way of obtaining maximum wartime production of potatoes. On areas without a green-manure crop or fertilizer treatment included in the cropping plan, a yield of 113 bushels per acre was obtained; while with the use of a green-manure crop of sweetclover in a long-time rotation a yield of 304 bushels per acre was secured.

PHYSICAL CONDITION OF THE SOIL AFFECTS YIELD

The use of chemical fertilizers by the farmer must be justified by the greater return secured from the extra yield produced. Variation in response from fertilizers with the same crop and soil under different systems of management has prompted the stations to investigate the effect of such physical factors as structure, moisture and air relations, and percentage of different-sized soil aggregates, or clods, on crop growth and yield.

Soil-structure studies by the Alabama station revealed that the best crop yields were obtained on soils containing clod mixtures varying in size from one-sixteenth to one-fourth inch and from one-sixteenth to one-half inch.

Chemical changes in soils.—Poor condition of citrus trees in plots receiving ammonium sulfate and sodium nitrate was investigated by the California station and found to be due to changes in soil structure caused by these chemicals, resulting in impaired penetration and poor aeration. The ill effects of the chemicals were partly overcome by the use of gypsum and coarse organic materials.

Legumes in rotation.—Beneficial effect of increased yields from legumes was concluded, from studies by the Kansas station, to be due to the favorable effect on the physical condition of the soil. The station points out that this physical condition largely disappears within 3 years and it is thus important that legumes be grown at relatively short intervals.

Soil permeability and fertility.—Investigations by the Mississippi station indicated that corn yields around 15 bushels per acre in the State were associated with a hard, dry subsoil, with no corn roots deeper than 8 inches. On other soil types that were better aerated and drained, some roots reached a depth of 80 inches. With this increased soil volume from which to obtain nutrients and water, much larger yields were produced.

Adequate soil oxygen supply.—The New Jersey station found this to be one of the most important determinative factors in plant growth. From controlled laboratory experiments, the station found that about 8 parts per million of air in the growing medium is below the optimum air required for some plants. Plants growing in soils with poor tilth or drainage cannot produce maximum yields, because the amount of oxygen present is much less than that required for the intake and utilization of existing soil nutrients.

MORE EFFICIENT USE OF FERTILIZERS

Production affected by fertilizer practice.—Without exception, the State stations have provided information on the kind, amount, and method of application of fertilizer for more efficient utilization by various crops. This information has been of great value in bringing about increases in production, as illustrated by the Michigan station's estimate that the 1943 crops produced in the State would have been less by 15 percent than the $300,000,000 of estimated value if fertilizers had not been used. According to the station, about three-fourths of the returns that Michigan farmers get from fertilizer applications come from the fact that the fertilizers are applied, and the other one-fourth from the use that farmers make of findings and recommendations of the Michigan station as to kinds of fertilizers to apply to soils of different types, or crops of different kinds and their placement. On this basis, the experiment station, in 1943, furnished a $10,000,000 service to a $300,000,000 industry.

Information on the use and function of fertilizer, manure, and crop rotation.—This information furnished to the farmers of Alaska from investigations by the Alaska station is a typical example of the efforts on the part of the stations to bring about increased production through more efficient methods. Many examples of increased produc-

tion as the result of the use of commercial fertilizer, manure, or lime could be cited. However, the need for and nature of response from these soil amendments is well established, and attention here will be directed to more recent advances in fertilizer practice that result from studies of soil conditions and plant response contributing to the more efficient utilization of fertilizer nutrients.

Boron increased crop yields.—In experiments conducted by the New Jersey station, the yield of red clover was nearly doubled by the use of 40 pounds of borax per acre, and a 20-pound application raised alfalfa yields as much as 1 ton per acre. Field studies revealed that approximately 12 percent of the cropped soils of the State were deficient in boron. The Sassafras, Lakewood, and Penn soil series were the soils most in need of boron for maximum production. Turnips were the best indicators of boron deficiency, as the flesh of the turnip develops brown discolorations when the soil is deficient in boron.

Zinc beneficial to cotton, corn, and peanuts.—A 3-year experiment by the Alabama station showed that including zinc in the fertilizer gave increases in yield of from 150 to 200 pounds per acre of cotton, about 5 bushels per acre of corn, and from 175 to 300 pounds per acre of peanuts.

Ammonium nitrate.—This chemical, now available for use in crop production, was found by the Mississippi station to be a good source of nitrogen. A 22-year test under Delta conditions with ammonium nitrate and nitrate of soda indicated that the two carriers were about equal. In other tests conducted in different soil types throughout the State, ammonium nitrate was found to be as good as or better than other sources of nitrogen for corn, cotton, and oats. The Alabama and Georgia stations also reported that ammonium nitrate gave satisfactory results.

Nitrogen supplies are larger.—More nitrogen is available for crop production, but problems have developed in connection with methods of application and use of some of the new carriers. Liquid ammonia is one of the carriers of nitrogen available for agricultural use that presented problems on methods of application. In order to use this carrier, the Tennessee station designed and tested a machine which will place any desired amount of liquid at any desired location with respect to the plants. The machine consists of a multiple-unit pump made by stretching rubber tubing over a revolving wheel and having one tube for each outlet. The pump is driven by a ground wheel, so that the application is constant regardless of speed. Each pump outlet is connected to an outlet pipe located on a machine, such as a disk harrow, a cultivator, or a plow, so that the liquid will be placed where desired and covered immediately with soil.

Deep application of fertilizers.—Such application is made possible by a fertilizer attachment for plows developed by the Indiana station. Placing fertilizer on the bottom of the plow furrow gave better yields than where the same amount of fertilizer was placed elsewhere. Approximately 7,000 of the attachments for deep placement of fertilizer were sold by one manufacturer this year.

Alkylation phosphate.—This product, obtained by treating rock phosphate with sulfuric acid which had been used in the manufacture of high-test aviation gasoline and contained some aromatic compounds rendering the acid unfit for further gasoline processing, was compared by the Ohio station with the usual commercial forms of 20-percent

superphosphate for growing plants. Various vegetable, agronomic, and flowering plants tested showed no harmful effects when alyklation phosphate was used at rates considerably above those that would be employed in the field. There was no material difference in soil reaction in the alkylation phosphate and superphosphate plots. As used, both types of phosphate increased the available phosphorus in the soil.

Sludge.—Sewage sludge was found by the Connecticut (State) station to compare favorably with barnyard manure for vegetable production. In view of the need for organic materials on vegetable soils and the general shortage of barnyard manure, the station points out that sewage sludge can be profitably used by vegetable growers.

Synthetic manure.—Synthetic manure produced from any kind of plant refuse, such as straw, cornstalks, salt hay, garden rubbish, soybean refuse, garbage free from metals and glass, grass clippings, leaves, needles of trees, weeds, peat, sawdust, and various industrial byproducts, treated and composted, was found by the New Jersey station to be a product that is economical and easy to prepare and provides an equally effective substitute for scarce animal manure for obtaining maximum crop production during the current period of limited supplies of fertilizer.

Developing fertilizer practices from soil studies.—As carried on by the Florida station, these studies are typical of the efforts of many stations to obtain maximum benefit from available fertilizers. Extensive studies of samples of typical soils of the State by the station revealed that most of the soils are rather low in total and soluble phosphorus and in total and exchangeable potassium, indicating the general requirement for these elements in pasture fertilization. It was further found that most of the potassium is in exchangeable form and thus subject to leaching, which indicates the desirability of frequent applications of this element. It appeared that an application of 50 percent of the annual treatment at the beginning of the year and the rest about midway of the growing season would be the most profitable.

Limestone.—Use of limestone was found to be an effective means of maintaining production with limited supplies of fertilizer in experiments conducted by the Mississippi station. Cotton following vetch treated with dolomitic limestone at the rate of 300 pounds per acre yielded as much as that fertilized with 600 pounds per acre of a 6–8–4 fertilizer.

As an aid in determining which soils would give maximum production of certain crops, the Virginia station determined from cooperative experiments the relative rating for different crops on each soil as well as the relative value of each soil for the production of each crop when given different treatments. With this detailed information, it is possible to plan production so as to obtain greatest yields.

Study forms of phosphorus.—The forms of phosphorus in the soils of Iowa and their availability to plants were investigated by the Iowa station. These studies provide basic information for the development of soil-management and fertilization practices which result in the more efficient utilization of the natural phosphorus in the soil as well as of that added by commercial carriers.

Plant composition as an index of fertilizer need.—From extensive field experiments with alfalfa, the New York (Cornell) station found that, if the potassium content of the alfalfa plants at the early-bloom stage was less than 1.3 percent, a yield increase of 20 percent occurred from potash fertilization. Plants having more than 1.3 percent of potassium seldom gave significant increases in yield with added potash.

The Indiana station, in cooperation with the Alabama, Georgia, and Mississippi stations, conducted tests with the Purdue plant-tissue test technique, in an effort to determine whether a deficiency of nitrogen, phosphate, or potash or a lack of nutrient balances or some other factors might be the principal causes for the numerous low corn yields in the South. Lack of nitrogen was found to be the major limiting factor. The tests showed that the practice of growing corn without adding nitrogen until about 40 days after planting generally resulted in nitrogen starvation during the early growth period. Unless winter legumes were well fertilized with phosphorus and potassium, nitrogen was available in such small quantities for the corn that followed the legumes that the plants were suffering nitrogen shortages at tasseling time. Approximately 2 pounds of nitrogen is required to produce a bushel of corn in the Southern States and Indiana.

The Pennsylvania and California stations continued to make advances in the development and application of leaf diagnosis to determine the relationship of yields to nutrition with respect to the major fertilizing elements under different conditions, thus providing the basis for greater efficiency in fertilizer use.

PRODUCTION INCREASED WITH SOIL CONSERVATION PRACTICES

Larger canning crops.—Yields of canning crops were increased by the inexpensive and soil-saving practice of contour farming, in experiments conducted by the New York State station. Yields of sweet corn and cabbage were increased 35 and 15 percent on Dunkirk silty clay loam soil as a result of contour planting. Quality of the crop and uniformity of maturity were also greatly improved. The differences in yield and quality are partly explained by the fact that from May to October there were 3.9 inches less run-off and 19 tons less soil loss where cabbage was planted on the contour.

Cooperative studies with the Oklahoma station and the Soil Conservation Service on a deep soil revealed that a complete system of conservation farming has maintained crop yields at about one-third higher level than continuous individual crops on unterraced fields, over a period of 12 years. Soil loss was reduced about 28 times and water loss 1.8 times.

Conservation practices increase corn yield.—Watershed studies, reported by the Indiana station in cooperation with the Soil Conservation Service, to determine the effect of soil conservation practices on corn yield and soil fertility showed that conservation practices increased the corn yields an average of 25.1 bushels in 1942 and 32.9 bushels in 1943.

Forage production increased with conservation.—Various types of vegetal material were used as surface mulches and incorporated into

the soil in studies by the Arizona station and the Soil Conservation Service to determine the effect on infiltration and erosion by means of artificial rainfall applied on small plots on two soil types located near Tucson, Ariz. Protection of the soil surface either by plants themselves or by organic litter which they furnish was found to prevent sealing of the soil and to be important in promoting infiltration of water into the soil, and to conserve moisture for plant growth. The results indicate that a 20-percent increase in conservation of moisture in well-vegetated areas may increase forage production by 50 percent.

Crop residues in erosion control.—Erosion and run-off were reduced, in Nebraska station experiments in cooperation with the Soil Conservation Service, to a point where they could not be considered serious in most cases when a reasonable amount of crop residue was left on the land. Crop yields were, in general, as high as by ordinary methods. Corn after second-year sweetclover was protected from erosion by the heavy residue, and no difficulty was experienced with tillage or cultivating implements. Results of this research are being utilized on an increasing number of farms and point the way to methods whereby a high percentage of the land in the Great Plains could be protected from the danger of another "Dust Bowl."

COVER CROPS, GREEN MANURE CROPS, AND MULCHING AID PRODUCTION

Nitrogen balance affects production.—Experiments at the Alabama station showed crop response to residual soil nitrogen was greatest on Hartselle soil and least on Decatur and Norfolk soils; crop yields were higher with vetch turned under than with summer legumes; and Norfolk soil lost the most nitrogen by leaching, with the greatest loss occurring where both vetch and soybeans were turned under. On Norfolk sandy soil, green-manure oats produced with ammonia nitrogen gave twice the yield obtained with nitrate nitrogen. Yields of corn following green-manure oats were related to amounts of nitrogen added to the corn as the oats induced nitrogen starvation.

Vegetable yields increased with green manuring.—A green-manure crop of cowpeas following spring vegetables helps to overcome the shortage of commercial fertilizer, according to results from the Oklahoma station, where the green-manure crop gave yields of potatoes comparable with those obtained from a 10-ton application of manure and commercial fertilizer.

Soil potash increased by straw mulch.—Through the use of a straw mulch, replaceable or available potash may be readily increased within a period of 3 years to a depth of 12 inches of Wooster silt loam soil, according to investigations by the Ohio station. Applications of potash fertilizer on the mulch gave a greater increase in the soil potash. Such increases in available potash are not possible on sod or cultivation because the potash becomes fixed in an unavailable form in the soil. Straw grown under an optimum level of fertility furnished more potash to the soil through leaching and was more resistant to deterioration than straw grown under a low level of fertility.

BETTER VARIETIES OF CROP PLANTS

Productive new varieties and strains of food, feed, fiber, and oil crops, bred by the experiment stations for high yields, regional adapta-

tion, resistance to diseases and insects, endurance of climatic extremes and environmental hazards, and for special industrial purposes have been rapidly replacing the sorts commonly grown. Many of the better field crops, vegetables, and fruits are products of research groups of the stations working cooperatively with the Department. Extensive improvement programs, some of them Nation-wide, are in progress with wheat, corn, oats, barley, rice, cotton, alfalfa, soybeans, peanuts, flax, potatoes, sweetpotatoes, onions, strawberries, tobacco, and other crop plants. The new varieties made available to farmers are the culmination of efforts over many years and have as their basis fundamental genetic research, perfected breeding methods, and extensive field and laboratory tests. Applied science has eliminated guesswork and has put into production many new varieties needed both for war and civilian uses.

IMPROVED CEREAL CROPS

Hybrid corn.—The development of hybrid seed corn has continued to depend in large measure on the State experiment stations, cooperating with the Department, in perfecting procedures, selecting superior inbred lines, testing combinations, and giving general counsel to seed-improvement associations and other hybrid-seed producers. Corn hybrids, making a gain in yield estimated at 20 percent over open-pollinated varieties grown under like conditions, have enabled farmers to obtain the increased production demanded by wartime conditions with relatively small increases in planted area and thus release acreage for other crops in emergency demand. The volume of the 1943 corn crop of 3,076,159,000 bushels from 97,136,000 planted acres, second largest on record in spite of many adverse conditions, could be attributed in large measure to use of hybrid seed, a noteworthy development from research of the stations and the Department. Hybrid corn was aiding growers in attaining the yet higher production goal on 100,253,000 acres in 1944.

For the Nation as a whole, departmental surveys showed an increase of hybrid corn from 143,000 acres, 0.1 percent of total corn acreage in 1933, to 56,818,000 acres, or 57 percent, in 1944. Hybrids were grown in Iowa on 99 percent of the corn acreage, in Indiana on 97, in Illinois on 96, and in Ohio on 94 percent; parts of Wisconsin, Minnesota, South Dakota, and Nebraska adjacent to those States also grew 95 percent or more hybrids. Of the 1944 total, nearly 52 million acres of hybrids were in the main Corn Belt. Zones with high percentages of hybrid acreage around the Corn Belt have widened and intensified as newly adapted varieties and silage varieties have developed. Throughout the United States, wherever adapted hybrids are available, their use had redoubled.

Adapted crosses.—These have appeared in considerable volume in Middle Atlantic and central Southern States and in Florida, and progress in adapting and adopting a hybrid-corn breeding program is evident in other Southern and Western States. As a result of an intensive hybrid-corn breeding program the North Carolina station has selected two yellow and two white double-crossed hybrids for early release to growers in the State. Their use, it is estimated, would increase acre yields by at least 12 to 20 percent over varieties commonly grown.

According to the Louisiana station, the acreage of Louisiana hybrid double-cross corn planted for seed production in 1944 is expected to produce enough hybrid seed to plant 110,000 acres in 1945, nearly four times as much as the 30,000 acres in hybrid corn in 1944. Since hybrid seed corn has increased the average corn yield in the State by 10 bushels per acre over open-pollinated varieties, a gain of 1,100,000 bushels on the 110,000 acres in hybrid corn in 1945 is expected.

A typical example of advances of hybrid corn is the decided superiority of a new midseason yellow and a new late white hybrid developed by the Nebraska station for the eastern part of the State. Seed stocks were available, and these hybrids were placed in production in 1944. Development by the station of a new early yellow hybrid—now being rapidly increased—and other early experimental hybrids would make increased production possible in western Nebraska. Starch of Nebraska Waxy proved a suitable substitute for tapioca starch, and 23,000 bushels of this variety were grown under contract for the starch industry in 1943.

Superior full-season dent corn hybrids.—Three such hybrids developed by the Kansas station and the Department and now in commercial production are K2234, a productive white corn for industrial utilization, and K1583 and K1585, to supplement earlier out-of-State yellow hybrids. They have outyielded the three better open-pollinated varieties over a 3-year period by 37 to 53 percent and have had 11 to 29 percent more plants erect at harvest. About 40,000 acres of these station hybrids will be grown in 1944. Popcorn hybrids K–1, K–2, K–3, and K–4—outstanding over 5 years—yielded over two-thirds more corn than the best variety and were equal or superior in all other agronomic and popping qualities.

A new corn hybrid.—Specially adapted for silage and fodder, a new hybrid, developed by the New Jersey station, has ranked in yield well above other varieties in the State, particularly in the central and southern sections. Since the kernels are a mixture of white and yellow colors and the ear is rather hard to husk, it is not recommended for grain production.

Losses caused by root, stalk, and ear-rot diseases of corn may be minimized when resistant hybrids are released to growers. Illinois station hybrids 200, 206, and 784 are reported to be resistant to diplodia stalk rot, while hybrid 960, though susceptible to this disease, is rated best for Illinois in ear-rot resistance. Combination of resistance to different diseases is in progress.

Corn leaf blight infection was general in 1943 over the southern two-thirds of Ohio. The Ohio station found that several established corn hybrids, differing in date of maturity, possess resistance to the disease. In addition, several new experimental hybrids proved to be highly resistant and are to be released as soon as possible. Growers, by selecting resistant types, may escape much of the loss from poor ear and kernel development, reduction of fodder value, or weak stalks due to leaf blight.

The possibility of improving the nutritive quality of corn protein by breeding was evident in a definite relationship between genetic constitution and amino acid composition of corn protein indicated in studies of single-cross corn hybrids by the Indiana station and the Department. In analyses of hybrid kernels for arginine, cystine, histidine, methionine, and tryptophan, one or more of these amino acids

were found to be higher (or lower in some cases) in hybrids for which certain inbreds had served as a parent as compared with other inbreds.

Additional services are rendered by many stations. For example, the Minnesota station, under an act of the State Legislature, is required to test all corn hybrids offered for sale in Minnesota and to determine the number of days from emergence above ground to maturity. Number of days to maturity must be given on the tag of every bag of seed offered for sale. In 1943 the station tested more than 400 hybrids, and the results were published as an aid in assuring that farmers will obtain corn hybrids adapted to their localities.

New wheats.—Although primarily in greatest demand as a food grain, wheat is now being used extensively as livestock feed, which in part accounts for the substantial increase from the 55,109,000 acreage harvested in 1943 to the 67,030,000 acres of the 1944 goal. Better wheat varieties are being perfected by station and Department breeders to replace older sorts exhibiting one or more faults or weaknesses objectionable to growers, processors, or consumers. The objectives are variously to combine adaptation to particular regions, high acre yield, and other desirable agronomic characters, resistance to diseases and insects, endurance of drought and cold, better milling and baking qualities, and superior pastry values.

Mida.—This variety is a new productive hard red spring wheat developed by the North Dakota station in cooperation with the Department and released in 1944, which has made higher average yields than Pilot, Rival, Thatcher, and Renown. The variety has stronger straw than Rival and heads a day earlier, has large dark-red kernels with high-test weight, and threshes easily, and has shown high resistance to leaf and stem rusts and stinking smut. Mida has also been found satisfactory in milling and baking qualities. Observations about some other varieties follow.

Wichita.—This early winter wheat, derived by the Kansas station and the Department from Early Blackhull × Tenmarq, surpasses Early Blackhull in yield, resistance to lodging, and quality, and is about a week earlier than Tenmarq. It has a high-test weight and about equals in yield the better adapted, full-season varieties in Kansas. Seed was expected to be available to farmers for quantity planting in the fall of 1945. According to the station, the newly distributed Pawnee wheat yielded up to 59 percent more than fly-susceptible varieties in 19 different locations in central Kansas in 1943. Pawnee usually carried about half as much infestation as other commercial wheats and showed materially less fly damage. It was developed by the Kansas and Nebraska stations and the Department.

Cache.—Cache, an awnless winter wheat resistant to smuts, lodging, and shattering, distributed to farmers in 1937 by the Utah station and the Department, has averaged about the same as Relief and Utah Kanred in yield, although surpassing them in resistance to smuts found in the region. It has acceptable milling and baking qualities and is currently the best variety available in a relatively pure state for dry lands of northern Utah.

Orfed.—This variety, a promising new white wheat developed by the Washington station and the Department from Oro × Federation, has a medium-sized kernel, semihard to soft in texture, high bushel weight, and satisfactory milling quality. It is described as resistant

to nearly all known races of stinking smut, does not shatter readily, and may be grown from either fall or spring sowing. Enough seed for limited field use was available in 1944.

Superior selections of the Tennessee station are Bluestem 2 (Purplestraw), a wheat usually outyielding other varieties and indicated for land naturally fertile or after tobacco, potatoes, tomatoes, or other fertilized truck crop, and the bearded Fulcaster 612, which may be grown successfully throughout the State, even on rather poor soil.

Henry.—Primarily a feed grain, Henry is a new high-yielding spring wheat, resistant to all common wheat diseases, developed and released by the Wisconsin station and the Department. Its large red semihard kernels may be milled into flour of fairly good baking quality. Henry has far outyielded Marquis and Thatcher wheats in Wisconsin and made 23 percent more yield than Sturgeon, heretofore considered the best spring wheat for the section. The new variety is expected to eliminate bad wheat years just as in the same region Vicland oats has done away with bad oats years.

Barley.—The increasing national importance of barley as a feed grain and pasture crop, as well as for industrial uses, as malt for alcohol, is evident in the 429,167,000 bushels harvested from 16,850,000 acres in 1942 and the goal of 17,372,000 acres in 1944. Barley acreage has expanded markedly in the Great Plains, but declined in the Corn Belt. Montana, for example, has made a noteworthy gain, attaining 15,939,000 bushels (five times the 10-year average) on 506,000 acres in 1943. The sudden shift from oats or wheat as a feed crop in Montana is attributed largely to the fact that barley has produced more feed per acre in total digestible nutrients than oats or wheat on either irrigated or nonirrigated land.

New spring barleys.—Compana and Glacier, developed by the Montana station and the Department in cooperation, are two of the new varieties that are major factors in achieving the bumper crops. Compana, released for production on nonirrigated lands of Montana in 1941, was grown on about 35 percent of the area seeded to barley in 1943. It is early maturing, high yielding, and resistant to drought and relatively so also to grasshoppers, and has produced yields from 15 to 20 percent above those of the older sorts, such as Horn and Trebi. Glacier, recently released for irrigated lands and better nonirrigated areas, is characterized by high yields, lodging resistance, earliness, and resistance to covered smut. Nearly 24 tons of seed were distributed from the station through the Montana Seed Growers' Association for the 1944 crop.

New Mexico Winter barley.—This variety, developed by the New Mexico station in cooperation with the Department, has been in large demand in the southern part of the State (irrigation) for both grain and pasture, because barley is produced more cheaply than corn and because combine harvesting of barley has materially reduced labor needs. Jackson No. 1, a new Tennessee station smooth-awned barley, has consistently given good performance and is being increased for distribution in the State.

Rojo barley.—This feed-hay variety, bred by the California station and the Department, is smooth-awned, resistant to lodging, and is adapted to coastal sections. It resembles Hero but matures earlier and is more resistant to scald and net blotch. Rojo has outyielded Atlas barley by 17 percent.

Velvon.—This smooth-awned, smut-resistant, stiff-straw barley is very popular in the intermountain areas of Arizona, Idaho, and Utah. Barley acreage in Utah has increased from 38,000 to nearly 200,000 since the development and distribution of Velvon by the Utah station. Sunrise and Davidson, products of cooperative research in North Carolina, are increasing rapidly. Other improved varieties, distributed by stations working with the Department, are Beecher in Colorado and Wintex and Texan in Texas.

New oats.—Conversion from the old oats varieties to new varieties resistant to rusts and smuts has gone on at a faster rate than did the change from open-pollinated corns to hybrids. The new varieties insure needed supplies of feed grain and forage and have made possible a considerable reduction in oats acreage to provide additional acres for war-emergency crops without reducing total oats production appreciably.

Outstanding new oats varieties were developed, tested, increased, and distributed by State stations cooperating with the Department. They include Boone (control), Marion, and Tama from the Iowa station, Vicland from Wisconsin, Cedar from Iowa and Nebraska, and Vikota from South Dakota, which combine high resistance to rusts and smuts with high productiveness and desirable grain characters. Estimates were that in 1943 half of the oats acreage of Iowa and Wisconsin, one-third that of Illinois, and 500,000 acres in adjoining States, totaling nearly 6 million acres, were sown to these varieties. New productive oats varieties for the South developed by similar cooperation include DeSoto from Arkansas, Lega from Georgia, Lelina and Letoria from North Carolina, Camellia from Louisiana, Fultex, Ranger, Rustler, and Verde from Texas, Quincy Red (Quincy 1) and Quincy White (Quincy 2) from Georgia and Florida, all resistant to crown rust and smut; and Pioneer from New Jersey, Wintok from Oklahoma, and Forkedeer, Fulwin, and Tennex from Tennessee, all winter hardy.

Experience in the several States confirm the merits of the new oats. In Iowa in 1944, 90 percent of the 4,905,000 acres planted to oats were in the disease-resistant varieties. Vicland oats, the Wisconsin station estimated, was grown on about 50 percent of the State's 1943 and about 90 percent of the State's 1944 oats acreage. Wisconsin farmers had produced 5,000,000 bushels of Vicland in 1942. Vicland averaged 78 bushels per acre in 1942, as compared with 53 bushels for other oats on farms throughout Wisconsin.

Tama oats.—Tama oats, averaging 74.8 bushels per acre, and Vicland, 74.4 bushels, produced the highest average and annual yields in recent tests at the Indiana station. Since the most productive disease-resistant varieties produced about 30 percent more grain than nonresistant sorts, including several varieties commonly grown in Indiana, the station estimated that 10 bushels per acre could have been added to the average yield of the 1,400,000 acres of oats in the State through use of these better varieties.

Rustler oats, along with other rust-resistant small grains such as Austin wheat and Tunis barley, developed by the Texas station and the Department, has found particular favor among farmers in the Gulf coast area, where leaf rust has been the principal deterrent to small-grain production. These strains are good grain producers and

also supply the great need for winter grazing crops, especially in times of protein shortages. Use of such winter grazing crops has a close relation in south Texas to livestock production, one of the major activities.

Other oat strains are: **Camellia oats,** the Louisiana station reports, has proved to be the outstanding variety in south Louisiana. The 175,000 bushels produced on 5,000 acres in 1944 should provide enough seed to plant the acreage of this variety needed in the State. **Westdale oats,** released by the California station and the Department, is resistant to stem rust, matures later than Kanota, and has coarser, taller stems. **Ventura oats,** also released by these cooperators, shows high resistance to stem and crown rust and to several types of smut. It ripens earlier than Kanota and has shorter straw, and the kernels are small and nearly white under California conditions.

Texas Patna rice.—This new variety, being distributed in Texas, resulted from a cross between Rexoro and another slender-grain rice from the Philippines, made in the cooperative breeding program of the Texas station and the Department. Texas Patna resembles Rexoro in grain type, yield, and quality, but matures about 10 days earlier and is equally disease resistant. Its earliness, as compared with Rexoro, provides a needed measure of safety in harvesting operations. Zenith, an early-maturing medium-grain variety developed in the cooperative breeding program of the Arkansas station and the Department, is now the leading early rice grown in the Southern States. The grain of Zenith is of better quality than that of Early Prolific. Zenith was grown on 18 percent of the southern rice acreage in 1944.

FIELD-GROWN FOOD CROPS

Potatoes.—The National Potato Breeding Program, in which 28 stations interested in potato growing and the Department are carrying on various phases of research, continued to bring forth superior new strains of potatoes. These supplement other new varieties that are already finding definite places in certain areas and aiding in producing the needed food indicated in the 1944 national goal of 3,519,000 acres. Yield, adaptation, resistance to diseases and insects, and quality have been major objectives. Some of the new strains are: Desota, a red potato, and Lasalle, a white variety, two seedlings grown by the Louisiana station, produce better spring and fall crops under Louisiana conditions than established varieties and show distinct resistance to mild mosaic. Potomac, formerly known as seedling B–247, named and distributed to other cooperating stations in the program and to growers by the Maryland station, has resistance to late blight and flea beetles and is a high yielder. The West Virginia station found that Potomac outyielded all other varieties under test, was less subject to insects and diseases than Sequoia, and was definitely less susceptible to soil rots. Kasota, the midseason potato introduced by the Nebraska and Minnesota stations, continued to be outstanding in extensive tests in Nebraska, showing resistance to fusarium wilt and producing tubers excellent in type. Enough seed was being grown in 1944 to put Kasota on a commercial basis in 1945.

Sweetpotatoes.—The extensive sweetpotato breeding and improvement program of 11 State stations and the Department was continued. The Louisiana station supplied seeds and seedlings not only in the

United States but in our island possessions and foreign countries. The two better table seedlings, 1x6–39–10 and 1x42–39–3, with about twice the carotene content of Porto Rico, were grown for commercial use in Louisiana this year and are being increased as rapidly as possible to supply Army requests for dehydration and canning. Quick-freezing tests have given excellent results. The L 4–5 seedling, also developed by the station, is now the leading starch and feed variety. In current tests with a commercial company 56 pounds of dehydrated L 4–5 potatoes yielded 5.15 proof gallons of alcohol, this being equal or superior to any of the grains.

Texas Porto Rico.—This is a selection of the Texas station which has proved satisfactory to growers. During 1940–43 it averaged 250 bushels per acre, as compared with 232 bushels from Louisiana Unit 1 Porto Rico and yields of less than 200 bushels for other strains of Porto Rico.

Field beans.—Sutter Pink is a new variety of beans developed by the California station from the cross Standard Pink × Early Pink. It is almost as early as Early Pink, produces heavier yields, and is superior in seed color and freedom from pits and wrinkles. Being 2 weeks earlier than Standard Pink, it may be planted as late as July 20. General use of the new variety is expected to increase markedly the quality of pink beans grown in the Sacramento Valley.

Strains of native beans, improved and distributed to growers by the Puerto Rico University Station, included a white strain (1160) outstanding in yield and quality and a pink selection (A–37), originally from the Dominican Republic, which definitely outyielded native red and pink selections.

New Mexico station tests on cooking qualities of its improved strains of Pinto beans, as determined by hardness of beans, water absorption, and tenderness of cooked product, showed that cooking qualities may be transmitted by hybridization.

NEW FRUITS AND VEGETABLES

A greatly increased interest in the products of the orchard and garden has followed in the wake of war and its disturbing effects on normal channels of supply. There has been a tremendous awakening of interest in both home and market gardens and a new consciousness of varieties, particularly varieties that are resistant to disease or insects and at the same time possess qualities that make them desirable for eating fresh or preserving. In response to this widespread interest and demand, the stations of the country have made a special effort to develop better varieties of fruit and vegetables for their respective areas. Evidence of successful effort is shown in the large number of new fruits and vegetables offered by the stations.

New fruits.—Since new fruits are not developed so rapidly as vegetables, fewer of them have appeared during the war period.

New strawberries.—July Morn, Crimson Glow, Sparkle, and Red Wing were originated by the New Jersey station. July Morn is a very late, firm-fruited variety suitable for quick freezing and preserving. Crimson Glow has high quality and is particularly suited for the home garden. Sparkle is a highly productive and red stele-resistant berry well suited for commercial production. Red Wing matures a

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late crop of very large firm fruits well adapted for commercial production.

The Montana Progressive strawberry, originated by the Montana station as a seedling from the well-known everbearing variety Progressive, surpasses its parent in commercial desirability because of complete freedom from yellowing of the leaves, a condition which has limited the usefulness of the original Progressive. The new strawberry compares favorably with its parent in quality and productivity. Considerable plantings of Montana Progressive have been made in the Bitterroot Valley.

Temple, a new strawberry originated by the Maryland station and the Department, is described as a midseason berry of very high quality. Because of its resistance to red stele, it is a very important introduction. Of the hundreds of American strawberry varieties, only a very few possess resistance to this disease.

Four new varieties of grapes.—Red Amber, Moonbeam, Blue Joy, and Blubell, developed by the Minnesota station from crosses between the extremely hardy Beta variety and high-quality eastern varieties, such as Agawam, Concord, and Delaware, were offered to the public during the year. These new varieties meet a need for table grapes for the north-central region, where intense winter cold has limited the growing of the established varieties of grapes.

New vegetables.—The new vegetables are numerous, and some fill pressing needs for adaptation to difficult environments. Mention is made here of only a few examples.

A promising new lettuce.—Lettuce No. 456 was developed by the New York (Cornell) station and the Department in their cooperative project in lettuce breeding. The new variety is of the crisphead or Iceberg type now so popular in eastern markets and practically replacing the old Boston types which dominated the eastern lettuce production for so many years. No. 456 produces solid marketable heads under conditions that cause Imperial 44, its predecessor in crisphead types of lettuce, to form puffy heads and tipburned leaves.

Early Grano onion.—This selection, developed by the Texas station cooperating with the Department, promises to be of great value, producing a heavy acre yield and maturing about 2 weeks earlier than other strains—a decided advantage in marketing. Seed fields now being grown in the El Paso Valley and the Pecos area from stock furnished by the station are expected to provide supplies of seed to the growers of southwestern Texas. Because of war conditions and the difficulty of obtaining good imported seed, new sources of high-quality onion seed are important.

California Hybrid No. 1, a new onion developed by the California station and the Department, marks a new departure in onion culture. As the name implies, this new onion is a true hybrid and, like hybrid corn, has to be obtained by returning each season to the original cross. The new hybrid is mild and sweet and highly productive. It is adapted only to regions of mild winter, where the seed can be planted in autumn and the crop harvested the next spring.

The Manatee Wonder pepper.—Originated by the Florida station and characterized by a pendant position of the fruits which protects them from sunburn, this pepper is described as a desirable new variety. The thick wall of the fruits gives them substance and reduces injury by blossom-end rot.

Ohiogold No. 1 sweet corn.—A new yellow hybrid, Ohiogold No. 1, bred by the Ohio station, was offered to the growers for trial in 1944. This new variety, the first in a series in a 3-year comparative trial, outyielded Golden Cross Bantam hybrid by 18 percent. The ears matured 6 days later, and the quality was rated higher than that of the Golden Bantam variety.

Northland sweet corn.—An early-maturing hybrid variety of sweet corn for the garden, the Northland, was released by the Maine station as suitable to the short, cool growing season of northern and eastern Maine.

Two new tomato varieties.—Red Cloud and Sioux, two new varieties of tomatoes selected by the Nebraska station from crosses between All Red and Stokesdale and made available to gardeners and commercial growers, have shown distinct merit in comparison with other varieties. Red Cloud, a very early sort, is recommended for producing early tomatoes on fertile soils in all parts of Nebraska and for a main-season crop in the cooler high-altitude areas. Sioux is a midseason-to-late, general-purpose variety. In comparative tests in the State, size and quality of fruit produced by Sioux have equaled those of the better standard late varieties and its yields have also been higher. Red Cloud and Sioux are being planted on more than 350 acres for commercial use, and about 3,000 home gardeners in Nebraska have received seed. Tomato production has been limited in eastern Nebraska by high temperatures and in western Nebraska by low temperatures and short seasons, but under all these conditions the new varieties may be depended upon to produce good crops.

Two new tomatoes.—The Pennsylvania station announced two new tomatoes, Stemless Pennorange and Stemless Pennred. Because of the stemless character, there are no stems remaining on the picked tomatoes to cause injury to other fruits in the container. The yellow variety, Stemless Pennorange, was found to be higher in carotene than red varieties and to have an ascorbic acid content equal to the higher range of values reported for red varieties.

Iroquois.—A new muskmelon, Iroquois, was developed by the New York (Cornell) station for growing on the fusarium-wilt infested soils of western New York. The new variety compares favorably with the older variety Bender, one of its parents, with respect to size, shape, and interior quality and fills a distinct need for a muskmelon to replace the older and less resistant kind, which has long been a mainstay in the Rochester and Buffalo market-garden areas.

Differences in the adaptability of varieties of vegetables for dehydration were determined by the New York State station. Among satisfactory kinds were Nobel and Heavy Pack spinach; Thomas Laxton, Canner King, and Pride peas; Copenhagen Market and Penn State Ballhead cabbages; Chantenay and Nantes carrots; Detroit Dark Red beet; Tendergreen snapbeans; and Golden Cross sweet corn.

FORAGE, PASTURE, AND RANGE

Improved grasses and legumes, as grown for harvest as hay, silage, and fodder and in pastures and on the range to be grazed off by livestock, were the main sources of the feed needed to provide the meat, milk, and wool, and, to an increasing extent, the poultry and eggs deemed necessary in the 1944 agricultural goals. The new varieties

developed by the stations and the Department not only make economical use of farm labor and relieve transportation but help to conserve the soil and maintain and increase its fertility.

Alfalfa.—Main objectives in the Nation-wide cooperative breeding program of the stations and the Department include at least three major types of alfalfa for adaptation to the northern, central, and southern regions. The desired characters are high yield and superior quality of forage, longevity, suitability to grazing, seed productivity, resistance to bacterial wilt, leaf spot, and other diseases and to such insects as pea aphids and leafhoppers. Through the Alfalfa Improvement Conference, organized in 1934, station, Department, and Canadian workers are making a concerted attack on these problems.

Buffalo alfalfa.—A strain from Kansas Common alfalfa, resistant to bacterial wilt, Buffalo alfalfa was selected by the Kansas station and Department and is now ready for market. It has proved popular over much of the eastern and southern parts of the United States. Buffalo is as hardy as its parent, but may be expected to hold a good stand for several years after Kansas Common has been killed out by wilt. Seed supplies of these varieties are being increased as fast as possible.

Nemastan alfalfa, selected from an introduction from Turkistan by the Nevada and Utah stations and the Department, has survived in the soils infested with nematodes and shows fair resistance to bacterial wilt. Since Nemastan is susceptible to leaf spot, it is not recommended for the Central and Eastern States.

Ranger alfalfa.—Developed by the Nebraska station in cooperation with the Department, Ranger alfalfa continued to show superiority in seed production and wilt resistance. It has been definitely superior to Turkistan strains in seed production and has equaled Grimm in cold endurance. Ranger fills an important need in the northern half of the United States, where bacterial wilt is a serious problem.

Hardy, productive alfalfas are needed by farmers in the Eastern States. Variegated alfalfas, as Ontario Variegated, Cossack, Baltic, Hardigan, and Grimm, have been the highest yielders of hay and the most winter hardy among alfalfas tested by the Pennsylvania station. Hardy common alfalfas from the Dakotas, Montana, Nebraska, and northern Kansas were next in value. Nonhardy common strains from States south of Kansas and from Argentina were lowest in yield and most susceptible to winter killing.

Sweetclover.—New sweetclover varieties bred by the Nebraska station in cooperation with the Department are superior in several respects to varieties currently grown and are promising for Great Plains farms. A new fine-stemmed, very leafy synthetic hay-type of sweetclover has made exceptionally good first-year growth. Varieties with late maturity and low coumarin content are also being developed, and the breeding of nontoxic sweetclover is expected to be sped up by perfection of a rapid test for coumarin. The Madrid, Spanish, and Evergreen varieties were outstanding in forage production, Evergreen being of particular value in prolonging the pasturing season in the second year.

Emerald, a new white-blossom annual sweetclover developed by the Texas station, has distinctive green seed, finer stems, and more branches, and is leafier than Hubam clover. Under close grazing, it

showed much greater recovery than Hubam and was pastured long after *Melilotus indica* had matured. Although Emerald has produced smaller yields of total forage than Hubam, it is a hay and grazing plant of better quality and should replace Hubam wherever annual sweetclovers are used for forage, particularly in irrigated sections.

Better pasture grasses.—A superior strain (1–i) of buffalo grass, developed by the Kansas station and Department cooperating, promises to provide farmers in western Kansas, a region of low rainfall, with another dependable hay and pasture plant. The grass is good also for airfields and cantonments, for it stands up under heavy duty. The 1943 seed crop of this strain, 5,000 pounds, was distributed to the public for increase and to the armed services.

Among new pasture grasses studied by the Florida station, Pangola grass (*Digitaria decumbens*) showed particular promise. It is relatively high in protein content among grasses tested and has made excellent yields in grazing tests with beef cattle. It is established readily by spreading and disking in mature stems and stolons.

Canada wild-rye (*Elymus canadensis*) in combination with sweetclover was found by the Iowa station and the Department to form a protective sod, practically to eliminate bloat, and to guard the land against soil washing between sweetclover maturity and corn-planting time. This grass endures drought and heat, and grasshoppers like it less than smooth bromegrass. Beef cattle have found the mixture palatable in its early leafy stages.

Weeping lovegrass (*Eragrostis curvula*), a bunch-type perennial introduced from South Africa, has made excellent stands and yields in tests by the Oklahoma station and the Department, is also a good seed producer and is easy to establish, has made a vigorous growth on a wide range of soil conditions, excels for erosion-control purposes, and has controlled weeds on poor, eroded soil. On average upland soil, three cuttings totaled 14,520 pounds of green forage. Two crops of seed from row-planted lovegrass usually make 250 to 300 pounds of seed per acre. Weeping lovegrass planted in rows and on the contour, with lespedeza broadcast on the surface the next spring, made excellent summer pasture.

Despite many introductions of promising grass varieties by the Georgia station, Bermuda grass continues to keep an important place in the pasture development in the State. Coastal Bermuda grass stolons were distributed to more than 300 farmers in 1943.

Range grasses.—The Colorado station and the Department determined that the proper source of seed of blue grama for range reseedings will result in increased forage production and grazing capacity; Arizona and southern Great Plains seed have surpassed local seed. Similarly, yields of bromegrass pastures may be increased by using certified seed of southern strains. Intermediate wheatgrass and Russian wild-rye in reseeding mixtures in foothill and plains areas also have increased pasturage for livestock. Reseeded pastures have complemented native forage on the range and have extended the productive grazing season.

Species found well adapted to reseeding deteriorated summer ranges by the Oregon station and the Department include crested, slender, bluestem, and bearded and beardless bluebunch wheatgrasses; smooth and mountain bromes; tall oatgrass; big and Kentucky bluegrasses;

timothy; orchard grass; meadow foxtail, Alta, meadow, Chewings, and creeping red fescues; and highland Astoria bentgrasses. Ordinarily, mixtures of several species should be sown for best results. Many of these species and combinations have produced far more herbage than native plants present before seeding.

Sorghum.—New improved varieties of grain and forage sorghums developed by the Kansas, Oklahoma, and Texas stations in cooperation with the Department are aiding in maintaining and extending production of feed grain and forage. Early dwarf types adapted to Nebraska and South Dakota have extended the grain-sorghum area. A number of the new sorghums brought out by the stations in these States are combine types which reduce costs and labor needed in production, and others are resistant to pythium and charcoal rot and to chinch bugs.

A new darso having resistance to milo disease has been selected by the Oklahoma station and the Department, and the seed has been made available to growers. Combine-type milos resistant to root and stalk rots are being increased. A new strain of Sumac sorgo (F. C. I. No. 1712), outyielding ordinary kinds by one-third in total crop and by one-fourth in seed, has been made available to growers in Oklahoma, where it is adapted to most of the State. Martin, a disease-resistant milo from Texas, has performed well in Kansas station tests, outyielding Westland, another superior combine-type grain sorghum, in north-central Kansas.

Cody.—This variety, a sorghum with waxy starch bred by the Department and the Kansas station, was grown in 1944 on 20,000 acres, mostly in Kansas and Texas. The starch from this crop was largely contracted for use in manufacturing a tapioca substitute.

SPECIAL CROPS

Soybeans.—The phenomenal expansion of soybean acreage and production in the United States from 1,782,000 acres in 1924 to 16,064,000 acres for all purposes in 1943 has kept pace with increasing demands for the crop as a source of raw material for industrial products and war munitions, a good feed for livestock and poultry, a nutritious human food, and a valuable aid to good farming, whether for seed, hay, pasture, or green manure. Although 10,820,000 acres were harvested for beans alone in 1943, the 1944 goal was set at 13,654,000 acres.

The rapid rise of the soybean to the status of a major crop has been based in large measure on the development by the experiment stations, the Department, and other agencies of superior varieties adapted to particular soils and climates, better cultural methods, improved machinery for planting and harvesting, safe storage practices, and better ways of using soybeans and their products. A survey by this Office revealed a total of 400 station projects concerned with different phases of soybean research active in 1944, including those in cooperation with the Department and the United States Regional Soybean Laboratory, an increase of 185 over 1936.

Earlyana.—A new soybean developed by the Indiana station and the Department and made available for commercial production in 1943, Earlyana is reported to be even superior in several respects to Richland, an early maturing soybean released previously by these cooperators and widely adapted to the richer soils in central Indiana. It is

adapted to conditions in north-central and northern Indiana and has the advantages of earliness, minimum loss of pods in harvest, and high yield of hay and oil. Earlyana grows relatively faster in early growth stages than other standard varieties, giving greater competition to weeds and permitting earlier cultivation.

Lincoln.—A new yellow seed soybean variety, Lincoln, is derived from a natural cross between a white-flowered Mandarin and Manchu first grown at the Illinois station. It was released by the Iowa station and the Department for multiplication in Iowa in 1943. It has outyielded a number of major soybean varieties in Iowa and other Corn Belt States, has lodged less than either Dunfield or Illini, and has surpassed Dunfield in percentages of protein and of oil and in the drying quality of the oil.

New soybean varieties released after development by the Louisiana station and the Department include L-Z, Acadian, and Pelican. These semiviney soybeans have proved excellent for interplanting with corn. They have given excellent coverage, with more growth than Avoyelles, which they outyielded by 10 bushels per acre when harvested for seed. Neither Acadian nor L-Z shatter in the field, an important factor because Louisiana farmers sometimes cannot harvest soybeans until late in December. Other soybeans being increased in 1943 included Nela, an excellent variety for northern Louisiana, and Mamotan 6680.

Gatan soybean.—Increased for distribution by the Georgia station, this soybean has for over 7 years averaged 6 bushels more seed and 0.5 ton more hay per acre than Otootan, previously the best soybean for hay. It has very fine stems and makes a high-quality hay.

The edible soybean has become a popular new crop in American agriculture, and a number of varieties, differing widely in maturity and adaptation, have been developed by the stations and the Department.

Mendota soybean.—A new edible variety, Mendota (developed from F. P. I. No. 84668) was released by the Wisconsin station in 1943. It is unusually uniform in plant type and maturity, very productive, and almost entirely free from crinkle mosaic. Its seeds reach the optimum stage for immature harvest in Wisconsin about 90–95 days from planting, about 10 days ahead of Bansei. About 30 bushels of seed were released in 1943 for increase, and a limited quantity was offered for production in 1944, although most were planted for further increase.

Kabott soybean.—Found by the Minnesota station to be very desirable for freezing, the Kabott, when ripe, has proved excellent for boiling, baking, and sprout production. Developed at the Central Experimental Farm, Ottawa, Canada, as a field variety, it is upright and productive and matures at least 2 weeks before Bansei. The pods do not shatter, even though the plants stand long after full maturity.

Peanuts.—Pearl, a white-skinned peanut improved by the Georgia station, breeds true and has resistance to certain peanut diseases. In yield it compares favorably with red-skinned Spanish peanuts. The skins of the latter type, if not removed by blanching, add color to the protein meal remaining after oil extraction. The white-skinned nut, the Department reports, may be pressed without the preliminary blanching process.

Martin County Runner, a peanut strain brought forward by the North Carolina station, has consistently made higher total and oil yields than strains of Virginia Bunch in northeastern North Carolina.

Cotton.—The income from Empire cotton, a selection from Stoneville by the Georgia station and the Department, has exceeded that from other varieties by from $2.22 to $13.75 per acre in north Georgia tests. It staples 1 to 1 1/16 inches under average conditions and 1 1/8 inches under optimum soil-moisture conditions and is characterized by earliness, large bolls, high lint percentage, productivity, resistance to thrips, and desirable fiber quality. Seed has been supplied to one-variety communities for multiplication.

Delfos 425–920.—A new cotton strain brought out by the Louisiana station and the Department, Delfos 425–920, has produced 2,735 pounds of seed cotton per acre with staple of 1 1/8 inches and has shown excellent wilt resistance.

Acala 1517.—A new cotton strain bred by the New Mexico station and the Department has proved to be one of the strongest fibered cottons in commercial production in the United States. Six tons of foundation seed were distributed to local groups of the New Mexico Crop Improvement Association. The strain, designated Acala 2815, is practically the same as Acala 1517 except that it matures earlier and is better adapted to the shorter season. Four tons of foundation Acala 2815 were distributed in the Pecos Valley.

Rowden 60A.—A strain developed by the Arkansas station and the Department, Rowden 60A is especially designed for harvesting by mechanical pickers. It has very short lateral branches and the bolls are borne close to the plant.

Tobacco.—Yields of tobacco in many counties of Kentucky have been substantially increased by disease-resistant varieties developed by the Kentucky station and released to growers in 1943. They include Ky. 16 and Ky. 41A, Burleys resistant to black root rot; Ky. 52 and Ky. 48, Burleys resistant to both black root rot and mosaic; Ky. 33, a stand-up Burley with resistance to black root rot, fusarium wilt, and brown root rot; and Ky. 120 and Ky. 134, dark fire-cured tobaccos resistant to black root rot. In Mason, Bourbon, Fleming, and Harrison Counties, where black root rot was found to be common, 90 percent of the 1943 tobacco acreage was planted to Ky. 16 and Ky. 41A, replacing root rot-susceptible varieties. Use of the resistant types save the growers $8,000,000.

Four strains of tobacco resistant to black shank disease, developed by the North Carolina station and the Department, were released for the 1943 crop and were available for commercial use in 1944.

BETTER WAYS OF GROWING, HARVESTING, AND STORING

The many considerations involved in the production of crops, apart from those relating to the soil and the choice of varieties, offer endless possibilities for improvement through research. So also do harvesting practices and the conditions under which agricultural products are stored. Especially pertinent in wartime are procedures which help to increase yields, reduce labor requirements, and contribute to products of higher quality at harvest and after storage. The State agricultural experiment stations through research and experimentation made available much useful information on these subjects in 1944.

The few examples given in the following discussion are grouped for convenience by types of crops.

CEREAL CROPS

Corn.—In Ohio station experiments, corn on plowed land has yielded from 10 to 15 bushels per acre more than that on unplowed land. Areas having the usual soil preparation made some gain over land plowed and then planted without further seedbed preparation, but even these yielded considerably more than plots prepared by the alternative procedures of roto-tilling, with subsurface tillage, and surface cultivation only. Many of the systems often proposed to replace the plow in corn production would leave considerable trash on the surface; this would be advantageous where erosion is serious, but a standard control measure to prevent corn borer infestation is clean tillage. The station believes that farmers should look with caution on any proposed system of tillage which would abolish or short-cut thoroughly tested practices.

Farmers in Ohio alone could increase the corn crop by 10,000 000 bushels by growing the optimum number of stalks per acre, according to estimates from planting experiments by the Ohio station and the Department. Part of this advantage would be attributed to the current widespread use of hybrid corn, which tolerates thicker planting than do open-pollinated corns. Indications are that on land of 40- to 60-bushel fertility levels, 3 kernels per hill may be more efficient, and 4 kernels on 60- to 80-bushel land and 5 kernels on 80- to 100-bushel land. Different rates of planting appear advisable in other sections. For example, in southern Ohio large late hybrid corn will yield best on 50- to 75-bushel land with 3 viable seeds per hill.

A sweet clover—common ryegrass mixture seeded in corn, the Michigan station found, provides effective erosion control and excellent green manure and markedly reduces the growth of annual weeds—but such seedings do compete with the corn. In general, corn with which a seeding had been made yielded within 2 to 4 bushels per acre of that grown alone.

Each of six corn hybrids at the Minnesota station showed marked reductions in yield when as many as three leaves were removed in detasseling. The average difference, as compared with not removing any leaves was 9.2 bushels. Three hybrids yielded substantially less when two leaves were removed, whereas none sustained more than a slight reduction when only one leaf was removed. Early maturing varieties had the greatest yield reductions when leaves were removed.

In Texas station tests, the efficiency of machine-harvesting corn was affected more by date of harvesting than by varietal characteristics. The moisture content of corn cut August 23 averaged less than 14 percent, indicating that early harvested corn may be safely stored and protected from weevils by fumigation.

Without injury to germination, ear corn for seed containing 25 percent moisture or less in the grain could be air-dried at 120° F., the Indiana station determined. Drying time was reduced about 20 percent by raising the air temperature from 110° to 120°. When the moisture content exceeds 25 percent, however, the entering air should not be above 110°. An air volume of 45 to 50 cubic feet per minute per

square foot of bin floor area gave the most economical drying. Little advantage came from reversing the direction of air flow during drying.

Wheat.—Cultural operations, soil fertility, and other environmental factors, as well as variety, may have definite effects on the milling and bread and pastry values of wheat. That wheat quality generally improves as soil fertility increases was shown by the Indiana station working with five varieties at three levels of fertility on three soil types. Wheat produced on well-fertilized soil was stronger in gluten, lower in carotenoid pigments, and higher in flour yield than that on soil low in fertility. Variety was the greatest source of variation and had the most influence in producing differences in components of quality studied. The station also determined that wheat grown on well-fertilized soil averaged about 10 percent more thiamine than that grown on unfertilized soil of the same type. Some varieties possess 20 percent more thiamine than others. Thus, it is evident that selection of varieties high in thiamine, combined with production on well-fertilized soil, tends to give grain of relatively high thiamine potency.

According to the North Dakota station, rather large variations in cultural treatments and crop sequence may be permitted on farms in the State without impairing the yield or quality of hard red spring wheat. Millet, unless followed by manure, has been definitely injurious.

Important changes in physical properties take place when wheat is wetted by rain after it is once dried, according to Kansas station experiments. The test weight is lowered, exteriors of the kernels become a dull yellow, and the endosperm is changed from a vitreous to a mealy condition. These changes, however, do not bring about any decrease in flour yield or impair flour quality. Loaf volumes and loaf textures have been as good in bread from the grain subjected to rains as in bread made from flours of wheats not subjected to rain. Frequent rains accompanied by storms during heading and ripening of wheat have had the same general effects as smaller rains; the greater mechanical losses in the field caused by them were not reflected in lowering of wheat quality.

Rice.—The increase of 10 bushels per acre in rice yields in California during 25 years, from about 60 to 70 bushels per acre, is accounted for in the main by the use of the Caloro and Colusa improved varieties, the use of ammonium sulfate, and changes in irrigation methods, made available by the California station and the Department, in conjunction with practical application of recent developments in the mechanization of rice culture. An example of the change in methods is the continuous-submergence method of irrigation, developed by these cooperators to control weeds in rice, which has become the standard practice on some 200,000 acres of old riceland. The rice is broadcast on the surface of the prepared seedbed, which is then submerged, or the fields are submerged and the seed is broadcast on the water surface, largely by airplane. The land, after seeding, is kept submerged until the crop nears maturity, being drained about 10 days before harvest. Barnyard grass, the most troublesome weed in the California rice area, is controlled by this method. Labor costs for weeding rice fields heretofore have ranged from $3 to $5 per acre. The binder-thresher method of harvesting has largely been replaced

by the combine-drier method with a marked reduction in labor requirements.

Fertilization of rice was found definitely profitable by the Louisiana station in most experiments made during 1 to 6 years in the rice area. A gain of 474 pounds of rough rice per acre was obtained for each 200 pounds of fertilizer used. Estimates are that the Louisiana rice crop could be increased about 10 percent if farmers observed the station's fertilizer recommendations.

An artificial farm-unit drier, devised by the Arkansas station, reduced the moisture content of rice 7.17 percent at a cost for fuel and electricity of 1.16 cents per bushel. Drying increased the value of milled products from 4.1 to 5.2 percent and did not affect germination. The drying process improved the quality of the rice and saved grain normally lost in the field as a result of excess moisture. Because of labor shortage, economy of harvesting, and improvement in milling quality, Arkansas rice farmers are encouraged to adopt the combine-drier method of harvesting.

FIELD-GROWN FOOD CROPS

Potatoes.—Maximum yields of quality tubers call for proper cultural methods, appropriate fertilization, and harvest and storage practices that will reduce damage, as well as adapted high-yielding potato varieties.

At 4 to 5 weeks after planting, potato stands from small whole tubers were better than those from freshly cut or suberized pieces, according to experiments by the Department and the Louisiana station. Plants from whole potatoes held their early lead and outyielded the others, suberized pieces being next best in yields.

Plantings 8 inches apart gave higher total yields of U. S. No. 1 tubers in Tennessee station experiments at Crossville, decidedly surpassing the yields from 16-inch or wider spacings, commonly used. Spacing for seed production evidently should be closer than for table stock, particularly with varieties like Katahdin, Chippewa and Sequoia, which have few eyes.

Copper, iron, and manganese applied by the Colorado station separately and in combination with sulfur and fertilizers have increased the red skin color of tubers of Red McClure and Bliss Triumph grown in the San Luis Valley and resulted in marked increase in quality. Benefits to growers and consumers from these experiments were evident.

A potato picking and sacking attachment for potato diggers, developed by the Montana station, has reduced from 11 to 6 the number of men required to carry on harvesting operations, thus bringing about a material saving in labor.

The ideal temperature for storing potatoes is 38° F., according to the Ohio station. At lower temperatures sweet flavor develops because some starch changes into sugar, whereas at higher temperatures sprouts begin to grow as soon as the natural dormant period ends. Since the practical temperature range is 30° to 50°, nearly any unheated basement free from rodents provides good storage conditions, and no special provision for ventilation is needed.

Sweetpotatoes.—Unabated demand for more sweetpotatoes for industrial and military uses, food for civilians, and as feed for livestock—

the goal for 1944 is 1,056,000 acres, an increase of 18 percent over 1943 harvested acreage—has provided additional problems of production and storage for station investigators.

The earliest plantings in 4-year tests of sweetpotatoes by the Tennessee station at Jackson gave the largest yield; plants set in the field in June may yield only half as much as those planted in late April or early May. Good yields of marketable roots, or U. S. Nos. 1 and 2, were produced at Knoxville at 9- and 12-inch spacings.

That borax is of value in preventing cracking of sweetpotatoes on the better soils and in improving flavor and texture, was shown in North Carolina station experiments. Where the roots have cracked badly, rates of application should generally be about 10 pounds, or 5 pounds per acre if the injury has not been serious. On the heavier soil types and where cracking has caused considerable loss, 15 pounds per acre may be broadcast; for beds, 1 ounce to 500 square feet of area may be used.

The conventional mechanical potato digger with minor changes was adapted by the Louisiana station for harvesting sweetpotatoes. For removal of vines to prevent clogging of the digger, a sugarcane stubble shaver gave best results. The digger also worked satisfactorily when the vines were dragged off with a plow or a sled equipped with a knife. Mechanical diggers and pickers for sacking the roots could reduce harvesting time for a yield of 200 bushels per acre, from 60 to 10 man-hours and the cost from about $18 to $5 per acre. About 60 percent of the acreage in 1943 could have been harvested mechanically, with a total saving to Louisiana growers estimated at about $850,000.

Storage of sweetpotatoes is a serious problem to growers, losses often ranging from 25 to 50 percent of the crop. The Maryland station determined that the amount of shrinkage in the Maryland Golden variety during curing and storage depends on the temperature-humidity combination used in curing. Least shrinkage took place with curing at 86° F. and 95 to 100 percent relative humidity, and the roots were in excellent condition at the end of 4 months' storage at 50° to 54°. The next best combination was 85° and 80–85 percent humidity. Properly cured sweetpotatoes evidently should not be exposed even temporarily below 50°, but the storage temperature should approximate 50°, and the humidity should be low enough to prevent condensation on the roots and to check sprout growth where not suppressed by temperature.

Prolonged exposure of sweetpotatoes to storage temperatures below the optimum range, the South Carolina station determined, may lower the plant-producing capacity of roots. At the end of the regular storage period, roots of Porto Rico sweetpotatoes were exposed to 40° F. for 4, 7, and 14 days; following 7- and 14-day exposures, the number of plants per root and per bushel decreased, the weight of root required to produce unit weight of plant increased, and marked rotting of bedded roots was induced.

FRUITS AND VEGETABLES

Mulching apple orchards.—The New Hampshire station found seaweed and hay to be useful materials in mulching apple orchards. With most of the apple orchards of the State in sod, obtaining adequate mulching materials is a difficult problem, particularly on rocky hill-

sides where natural grass is limited in amount. In general, the result of 2 years' work in comparing hay, seaweed, sawdust, and natural cover showed that mulching with hay or seaweed resulted in more and larger apples than did the other treatments. Fruit color was not so good on the hay and seaweed plots, but there was enough color present to meet the requirements of the fancy grade.

Mulching with hay was highly beneficial, according to studies by the Massachusetts station, in a 26-year-old McIntosh orchard which had been in cultivation for many years with no applied fertilizer. Before mulching the trees were in an unthrifty condition, with poor leaf color, little new growth, and declining production. In the season following mulching there was a well-marked improvement in the trees and their productivity. In fact, the hay-mulched trees became more fruitful than adjacent trees in sod with applied fertilizer.

Removing ethylene and other gases.—Brominated activated carbon was found by the New York (Cornell) station to be a useful agent in removing ethylene and other gases from the air of apple-storage rooms. The gases given off naturally by ripening apples hasten maturity and produce scald of apples in storage. Oiled paper in the containers commonly used at present to delay ripening and prevent scald had some effect in retarding the softening caused by ripe apple vapors but was not so effective or so cheap as the brominated activated charcoal.

Keeping Concord grapes.—Concord grapes retained their firmness longer and kept juicier in an atmosphere with an increased percentage of carbon dioxide than in ordinary cold storage, according to investigations by the New York (Cornell) station. However, the tendency for berries to separate from the stem, a characteristic of the Concord and related varieties, was not reduced by the carbon dioxide treatment.

Preventing excessive shriveling.—Prevention of shriveling with accompanying loss of water in fruit in storage is a problem for fruit growers, particularly in farm storages where good control of relative humidity is difficult. Certain varieties of fruit, notably the Golden Delicious apple, are particularly susceptible to shriveling. Earlier work at Maryland and other stations and by the Department had shown that covering the fruit with a thin layer of wax would prevent rapid loss of water and conserve the firmness of the fruits. The New York (Cornell) station designed an inexpensive machine that would apply a light coat of wax to the fruit. The machine has a capacity of 300 to 600 bushels per day dependent on the speed of operation. The cost per bushel for treatment is moderate, and the waxed fruits are attractive in appearance and retain their marketable condition over a much longer period.

A delay of 10 days between the harvesting and storing of Stayman Winesap apples was found by the Maryland station to result in as much softening as occurred in 60 days of storage at 30° F. in comparable fruit placed directly in storage following picking. Waxing 5 days after harvesting retarded the rate of softening after 3 months of cold storage and resulted in firm juicy fruits upon removal from storage. Waxing 10 days after harvesting had much less effect. Precooling lessened the loss of firmness during the first 3 months of storage but had no effect during the second 3 months or in the post-storage period.

Pliofilm wrapping.—Wrapping of various vegetables in pliofilm was found in further studies by the Florida station to increase materially the satisfactory period of keeping, provided the vegetables were stored at favorable temperatures. Sweet corn handled in pliofilm wraps kept in marketable condition three times as long as comparable unwrapped corn. The use of pliofilm wraps permitted the harvesting of tomatoes in a more mature condition than is customarily attained, and as a result better-quality tomatoes were offered consumers in distant markets.

Saving labor in thinning.—Material labor savings in the costly task of thinning fruits were forecast by the Idaho station as the result of a study in 1943 of the new caustic spray method of reducing the set of fruit. The technique has been under study for some time by the Department and various State stations. In the Idaho trials a total of 25 different materials, concentrations, and combinations were used. The results were so promising that several commercial orchards were sprayed in 1944 with the most successful material, Elgetol, dinitro-*o*-cresol. Preliminary evidence was obtained that ammonium sulfate may be used effectively as a blossom-killing spray either alone or in combination with Elgetol.

Collecting frames designed by the California station provided a means of saving labor in the harvesting of French prunes in the interior districts. The frames are used in conjunction with mechanical tree shakers. In the upper Sacramento Valley in 1943 this method of harvesting resulted in increasing the output of prunes per man from two to five times compared with usual practices of hand shaking and hand picking from the ground.

Soil reaction and soil fertility.—That soil reaction as well as soil fertility is a factor in the successful culture of vegetable crops was noted in experiments reported by the South Carolina station. Carrots and beets were shown to be rather sensitive to the reaction of the soil, with no marketable roots produced on soils more acid than pH 5.0. Plants grown in the pH 5.0 to 5.5 range were slow in attaining the marketable stage, requiring some 10 to 14 days longer than the same varieties grown at pH 6.0 to 6.5. Lettuce was very sensitive to soil reaction, with the plants grown at pH 6.0 to 6.5 maturing earlier and producing better-quality heads than those on more acid soil. Snap beans proved less sensitive to soil reaction than most of the vegetable crops grown in the study.

Optimum beet-growing temperatures.—Optimum temperature requirements for garden beet varieties were noted by the Texas station in field experiments conducted near Iowa Park, and varieties were found to differ materially. The best temperature for increase in fresh weight of the Crosby Egyptian beet was about 68° F., daily average, while that of the Early Wonder variety was approximately 73°. These results should be helpful to growers in selecting varieties best adapted to the season in which they are to be grown.

Tomato transplanting studies.—Studies on tomato transplanting carried out by the New Jersey station with tomato seedlings grown at different levels of phosphorous and nitrogen nutrition showed the desirability of growing the young plants in a soil low in phosphorus and medium in nitrogen. Such seedlings possessed sufficient storage reserves for abundant root initiation and rapid recovery after trans-

planting. Plants stimulated by excessive nitrogen did not resist transplanting as well as those grown at moderate levels of nutrition. Thousands of acres of tomatoes are grown in New Jersey from transplanted stock, making this information very much worth while.

Wax bean blossom drop.—Blossom drop in wax beans may be reduced by dusting the plants in bloom with naphthalene acetic acid, according to the Wisconsin station. Yields were increased by approximately 15 percent in both 1942 and 1943, and the treatment returned a profit to the growers. This discovery offers possibilities for increasing the production of a major food crop.

Indolebutyric acid emulsion.—An emulsion of indolebutyric acid proved the best of various growth-promoting substances applied by the Ohio station to the flowers of greenhouse tomatoes in an attempt to increase the set and percentage of well-filled fruits. Certain other materials used resulted in a high percentage of fruits with partially hollow cavities and distorted shapes. As a result of the station's work, something over 1,600 pints of indolebutyric acid emulsion were supplied by the Ohio Hothouse Growers Association to tomato growers in 1944. This was enough material to treat two clusters to a plant on 135 acres of greenhouse tomatoes.

The practice of treating various transplants with a starter solution made up of sulfate of ammonia or a combination of sulfate of ammonia and superphosphate has been found to be especially valuable under short-season conditions, according to results obtained by the Montana station. Yellow Globe onions produced a yield of 433 bushels per acre from untreated transplants, while transplants treated with nitrate of soda and sulfate of ammonia produced 568 bushels per acre, or an increase of 31 percent. Sweet Spanish onions gave an increase of approximately 15 percent as a result of the transplant treatment. With a crop requiring a longer season, such as tomatoes, the transplanting treatment gave an increase of 50–100 percent from different transplant fertilizer treatments, either alone or in combination.

Direct seeding of tomatoes.—Direct seeding of tomatoes in the coldframe as compared with the old method of transplanting from seedbeds to coldframes was found to have important advantages, beside labor-saving advantages, in experiments at the California station. The reduced handling in direct seeding materially reduced the prevalence of the mosaic disease, with consequent increases in yields. Direct seeding also largely eliminated losses from damping-off, a serious fungus disease of seedlings. The seeding rate was about 25 seeds per foot of row, and the plants were thinned to approximately one plant per inch of row as soon as possible after all the plants were up.

Interplanting standard tomato varieties.—Interplanting of standard varieties of tomatoes, such as Rutgers or Marglobe, with the early maturing variety Victor was found by the Virginia Truck station to give a material increase in total yield per acre over that of a standard variety planted alone. The earliness of the Victor tomato lengthened the production period and increased yields in the early part of the season and contributed to larger total yields. Since early maturing fruits usually command a better price, the returns to the growers were increased correspondingly.

FORAGE CROPS

Alfalfa.—Better methods for the establishment and management of alfalfa and more productive haying and pasture practices have been developed by the Colorado, Michigan, Washington, and other stations.

Making alfalfa seedings in several localities, the Ohio station observed that the "trash mulch" method of direct establishment of alfalfa-grass meadows on "worn-out," badly eroded hill lands of eastern and southeastern Ohio is very promising as a means of restoring productiveness. The station has generally found it more profitable to follow alfalfa with another crop for 1 year before reseeding to alfalfa, for attempts to prolong the life of old alfalfa meadows by sowing more alfalfa seed have usually failed. Old alfalfa meadows may be reseeded successfully to timothy, after which a mixture of alfalfa-timothy hay can be harvested for an additional year or two. Timothy will fill in open places otherwise occupied by weeds.

Sweetclover.—Sweetclover, the Ohio station finds, is the best soil-improving crop available to shorten and intensify wartime rotations without seriously lowering soil productivity. In fact, the most intensive grain-farming rotation possible has been the 2-year sequence of wheat or oats, in which sweetclover is spring sown and plowed under the next spring for corn. This corn is again followed by small grain with a sweetclover catch crop. Corn yields have been maintained or even substantially increased by such rotations.

Hubam annual white sweetclover grown by the Texas station as a crop for hay or seed in the Blackland region in a 2-year rotation with cotton has doubled the yield of cotton as compared with continuous cotton and has increased yield of cotton over one-third as compared with that in a cotton-corn rotation, and has reduced cotton root rot. Corn in the corn-Hubam rotation yielded 28 percent more than continuous corn but only 18 percent more in a corn-cotton rotation. In the rotation where Hubam was used for hay it produced 1.62 tons per acre. Hubam may also be grazed either in a mixture with small grain or alone.

Forage crop seeds.—Increasing emphasis on improved pastures and meadows for the purpose of expanding meat and milk production and thus meeting greatly enlarged wartime demands and supplementing short supplies of seed of important hay crops has given new importance to the growing of forage-crop seeds and to associated station research. Goals for hay-crop seed reached 4,890,000 acres in 1944.

Rapid increase in the acreage of smooth bromegrass in Michigan and other States has stimulated interest in seed production. The Michigan station, from its research, has elaborated effective cultural and harvest practices for producing smooth brome seed either from pure bromegrass stands or bromegrass-alfalfa mixtures, a good pasture combination also making very desirable hay. More than 90 percent of the bromegrass seed crop of the State is harvested from such mixtures.

Adaptation of a corn planter by the Pennsylvania station to plant fescue, orchard grass, and other pasture plants in rows for seed, enables even and economical distribution of small quantities of seed. Seed mixed with superphosphate alone or with lime is sown at the desired rate in rows following the contour and just after a small-grain crop.

After harvest of the small grain, the rows of grass are cultivated and harvested for seed the next year.

The finding by the Florida station that Pangola grass and improved strains of Bermuda grasses may be established by spreading and disking-in mature stems and stolons offers a way for prompt utilization of these desirable new pasture plants.

Shortage of grass seed has hampered needed pasture improvement in many southern areas. Studies by the Georgia Coastal Plain and Georgia stations with the Department indicate that controlled burning effectively stimulates seed production in old Bahia and Bermuda grass sod. Bahia and several other southern grasses tend to reach a peak in seed production the year after they are sown, and seed yields decline thereafter. When old top growth had been removed by burning, the seed yield from Bermuda increased two to three times and that from Bahia three to five times.

Burning fescues in the spring before or at the time of new growth, the Pennsylvania station discovered, resulted in little injury from silver top or white ear, a fungus disease hard to control. The increases of 80 to 100 pounds of seed per acre obtained on burned over unburned plots, at current seed prices, practically covered production costs.

Grass-seed studies by experiment stations cooperating with the Department have shown that, of the available fertilizing elements (nitrogen, phosphorus, and potassium), substantial increases in seed yield have been obtained only through use of nitrogen. Economically profitable increases in yield of seed from application of nitrogenous fertilizers were obtained with bromegrass at the Nebraska station; with orchard grass at Beltsville, Md.; with Bahia grass at the Louisiana station; and with Chewings fescue, red fescue, perennial ryegrass, orchard grass, Reed canary grass, and tall oatgrass at the Oregon station.

Seed yields of alfalfa, crimson clover, and hairy vetch, the North Carolina station found, were increased by applications of borax on soils low in available boron, and borax (5 pounds per acre) also improved the grade quality of peanuts.

Carpet grass and Bahia grass for seed, the Florida station has shown, may be satisfactorily combined directly from the field without previous curing of seed and hay. It found too that seed of white clover, black medic, and sweetclovers could be cleaned satisfactorily with a combine and dehulled with a hammer mill.

Buffalo grass seed contains much hard seed that does not germinate promptly. In recently harvested seed, germination as low as 5 percent before treatment is not uncommon. Germination of seed may be raised from 60 to 80 percent after treatment by a method developed by the Kansas station. Essentially, the treatment consists of soaking the seed for 24 hours in a 0.5-percent solution of potassium nitrate (saltpeter), chilling it wet for 6 weeks at 41° F., and then drying at once at temperatures under 120°. From 45,000 to 50,000 pounds of seed were being processed by the Fort Hays substation for seeding Army airfields and other military areas throughout the southern Great Plains.

Meadows and hay.—More effective cultural and harvest practices and improved grasses and clovers developed by the experiment stations and the Department, to a large extent, have made possible the

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record hay crops of over 105,000,000 tons of hay in 1942 and nearly 100,000,000 tons in 1943 (74,417,000 acres of all hay) and aid further in providing the still greater production desired by the 1944 goals.

Better management of mountain meadows is being obtained by Colorado ranchmen following practices found advantageous by the Colorado station, including seeding alsike clover, intermittent irrigation, fertilizing the meadows, and discontinuing heavy grazing in spring. Where the average yield of meadow hay for the county is 1.1 tons, an average of 2 tons of hay per acre of higher nutritive value is being harvested on meadows where the better management practices are followed.

Barley and hairy vetch consistently produced more hay than any other combination of small grain and winter legumes tested by the North Carolina station. Barley and vetch followed by Sudan grass and soybeans resulted in total annual yields consistently around 4 tons per acre both on clay loam soils of the Piedmont and on the fine sandy loam of the upper Coastal Plain.

The importance of securing the best quality and most favorable yields of hay, considering both digestible protein and total digestible nutrients, is emphasized by current needs for feedstuffs. Vermont station findings are that timothy should be cut when the bloom first shows and not later than full bloom; clover, between the one-third and full-bloom stage; and alfalfa first crop, starting not earlier than one-tenth bloom and finishing not later than half-bloom stage. Bloom may be somewhat more advanced for the second cutting.

Proper curing of hay has always been difficult in regions of low summer temperature, high humidity and frequent rains, and poor quality or spoiled hay often has resulted in these regions. Working in the Upper Peninsula, the Michigan station found that wilted green hay, free from external moisture, could be cured on tripods during adverse weather conditions with only a slight loss in quality. Hay in properly constructed tripod stacks cured satisfactorily and retained most of the leaves and also the green color, except on the small exposed surface. Field curing on poles or tripods costs but little more than the standard method used heretofore.

A superior quality of hay which retains all leaves and much more color and carotene than is common in fully field-cured hay has been obtained in the method of partial mow drying carried out at the Ohio station on second-cutting alfalfa. Hay only partly dried in the field is placed over a series of air ducts built in the bottom of the mow from common lumber. Air is forced through these ducts by a fan powered by an electric motor or gas engine. Chances of damage to the hay from rain are greatly reduced, for hay of 50 percent or more dry matter can usually be obtained by midafternoon of the day it is cut. In general, the cost is small compared with the benefit derived. Hay made in good weather or cured in the mow-drying unit ranged from 30 to 60 parts per million of carotene; whereas weathered hay exposed to several rains and stored in stacks in the field contained only 6 parts per million of carotene.

Hay barn-cured at the Indiana station by heated air forced by an electrically driven fan through a series of ducts had about two times the carotene content of field-cured hay that had not been rained on. Long hay composed of about equal parts of alfalfa, bromegrass, timothy, and clover, with an initial moisture content of 40 percent, was

dried to 15 percent moisture at a cost for electricity of $1.64 per ton of hay. Drying of alfalfa and bromegrass hay chopped to an average length of 3 inches, with initial moisture content of 28 to 30 percent, cost $1.99 per ton.

Alfalfa hay cured in sunlight lost more carotene than hay cured in the dark in Kansas station experiments, and hay cured in shade retained its carotene better than that cured under sunlight in the field. Windrowing alfalfa soon after cutting aided in retaining the carotene during curing.

Pasture plants.—Alfalfa and bromegrass have proved their value in a mixture used widely for pasture and hay in Michigan, and, according to the Michigan station studies, have been particularly effective in production of pasturage during July and August, when many pasture plants become brown and dormant and yield little nutritious forage. The mixture also develops a turf, which prevents soil erosion, and benefits crops following in rotation. The merits of this combination have been confirmed by pasture experiments of the Indiana, Ohio, and other stations.

Among 10 cool-season pasture grasses, bromegrass ranked highest in palatability to steers on a seasonal basis and reed canary lowest, according to tests by the North Dakota station with the Department, in the northern Great Plains. Russian wild-rye was low in palatability in the early season but was preferred later. Mature crested wheatgrass was low in palatability. Big bluestem ranked highest among 8 warm-season species, and buffalo grass lowest on a seasonal basis. Little bluestem was palatable in the early season but was avoided when mature.

Pasture fertilization.—On seeded pastures on Rayne silt loam, studied over a decade by the Pennsylvania station and the Department, nitrogen greatly increased yields in the early part of the season, but only with the highest application did it consistently increase production after June. Phosphorus in superphosphate gave large increases in production and by far the greatest net returns. Potash gave slight but consistent increases in yield.

Under grazing conditions, studies by the Wisconsin station with the Department indicated that production of permanent pastures can be increased materially and profitably by nitrogen fertilization and use of alfalfa reestablished periodically by renovation. These measures counteract the marked tendency for yields of dry matter and crude protein to decrease as pastures grow older.

According to Connecticut (Storrs) station experiments, an average of 200 pounds of limestone and 100 pounds of 20-percent superphosphate per acre per year will maintain good permanent pastures on soils similar to Charlton fine sandy loam. Seeding and proper management of legumes, such as Ladino clover, appear to be a much better method of maintaining an adequate supply of summer pasturage than the intensive use of nitrogen fertilizers on grasses.

Improvement practices.—Burning of native grasses in the flat woods area by the Florida station has resulted in new growth higher in protein and essential minerals and lower in carbohydrates and fibrous woody materials than is provided by unburned pasture. This improvement in composition and growth has persisted for 2.5 to 3 months after burning, after which the composition of the plants resembles that before burning. Controlled burning and seeding have

offered a satisfactory method of establishing carpet grass under range conditions.

In the process of improving pastures, the West Virginia station showed, preparation of the seedbed with a disk or spring-tooth harrow has given better results than plowing the sod, especially for establishment of legumes and reducing erosion. Both plowing and harrowing accompanied by liming, fertilizing, and seeding returned better yields of pasturage than did surface treatment.

Range practices.—Production on range lands must be geared to meet the need of armed forces and civilians for meat and wool and still conserve range resources for continued use in peacetime. The Arizona and New Mexico stations cooperating with the Department and other Federal agencies, on the basis of extensive research and experience, have focused attention on the "vegetation signposts" that indicate range conditions and have outlined practices that will assure continued maximum production of forage and livestock, as well as improvement of depleted ranges. Other stations in the West have provided like services to ranchmen.

Conservative season-long grazing has produced more beef per acre in Colorado station studies than deferred rotation grazing on foothill ranges in good conditions dominated by western wheatgrass, buffalo grass, and blue grama. Deferred grazing appears advantageous in improving depleted ranges dominated by perennial bunch grasses, such as green needlegrass and needle-and-thread grass, which depend upon seed production for perpetuation of high-density stands. Marketing livestock in early fall, mid-September to mid-October, from the foothill ranges has resulted in maximum income, for from one-fourth to one-half of the total seasonal gains may be lost by too late fall grazing.

SPECIAL CROPS

Soybeans.—Good production and handling practices, as well as improved varieties, have been essential in the extension of soybean growing. Efficiency in production methods is continuously sought by the experiment stations.

Although soybeans have not responded as well as alfalfa or corn to direct applications of phosphorous and potassium, experiments of the Iowa, Illinois, and other Midwest stations show that they do return higher yields with good soil-management practices. Use of lime and fertilizers in the rotation where needed, contouring on rolling soils, and especially application of manure, contribute to high acre yields of soybeans.

Soybean yields and the oil content of the seed decreased as planting was delayed beyond May 1, whereas protein content appeared unaffected in planting experiments by the Illinois, Indiana, and Iowa stations and the Department, made during three seasons with five varieties at five dates from May 1 to June 15. Early planting within these dates evidently will result in higher total oil yield per acre.

Increases in yields of from 20 to 50 percent were obtained by the Puerto Rico University station from all varieties of soybeans tested when planted in drills 1 foot apart as compared with the usual distance of 2 feet apart. Close planting also reduced weeding requirements. The Seminole variety has been outstanding in production of seed and forage and as an edible soybean. Indications are that the

soybean warrants a much larger place in Puerto Rico agriculture than it has occupied heretofore, both as food for human beings and feed for livestock.

Peanuts.—The wartime need for vegetable oils and the merits of the peanut as a direct food crop have resulted in further large increases in acreages of this oil and high-protein crop. To aid in reaching the Nation's goal set at 6,158,000 acres in 1944, the Georgia and South Carolina stations and the Department have determined the soils in these States suitable for peanuts, their extent and location, effective cultural and harvest practices, production costs and returns, and production possibilities for future needs.

In the southeastern Coastal Plain where Spanish peanuts have predominated in the past, the North Carolina station showed that higher yields of nuts and higher oil returns per acre can be obtained with Virginia Bunch when adequate quantities of calcium and potash are applied. Top dressing plants with 75 pounds of potassium chloride at emergence and applying at least 400 pounds per acre of gypsum to the foliage at time of blooming is recommended.

Both Spanish and runner types of peanuts have responded substantially in yield to lime in Alabama station tests. The value of lime for peanuts is evident in a great increase in use of limestone for the crop in certain Alabama counties, where as much as 60 percent of the cropland is planted to peanuts.

Cotton fiber quality.—Defoliation of cotton with calcium cyanamide (20 to 30 pounds per acre) when the bolls were 30 to 40 days old did not reduce the yield or the fiber or seed qualities at the Mississippi station. Defoliated machine-picked cotton has a slightly better market grade and less spinning waste than cotton machine-picked without defoliating. Yarn spun from machine-picked cotton was equal in appearance and slightly superior in strength to that spun from hand-picked cotton, but the spinning waste was greater.

Spining tests by the Texas station and the Department have shown that a Texas-grown cotton with shorter staple than the same variety grown in Mississippi possesses the same spinning utility, an attribute estimated heretofore on the bases of staple length and grade. The discovery that length of staple alone is not a true measure of spinning utility in cotton should increase the supplies of cotton of high spinning utility at a time when this value is needed by the armed forces.

WEEDS

Weed control.—Best returns from farm land and maximum values from crops and livestock and their products require control of weeds as well as other crop pests by practicable farm operations. To this end, the stations and the Department have continued their researches on the life histories and the physiology of weeds and on their control by chemicals, cultivation methods, smother crops and grazing, and other measures, and on the merits of herbicides.

The gravity of the problem is evident in the Minnesota station's estimate that loss to flax growers in the State from weeds in the 1941 flax crop alone probably exceeded $3,000,000, including loss in yield of seed from weed competition, reduction in marketability of flax straw, and cost of shipping dockage to market. Removal of dockage at country shipping points has had some merit as a temporary

measure, but the station finds that the most logical place to combat the problem is on the farm, by planting clean seed on clean land, crop rotation and frequent use of cultivated crops, early seeding, sowing legumes and/or grasses in mixture with flax as companion crops, and use of weed sprays.

Field bindweed.—Because of its effects on crop plants field bindweed is the most destructive weed in many Corn Belt areas. Extermination of bindweed by fallowing, the Iowa station and Department find, requires cultivation for 3 consecutive years at 10- to 12-day intervals throughout the growing season. Sorghum, in particular, and Sudan grass and millet have been effective smother crops when heavily seeded for several years on bindweed-infested areas. Soybeans seeded solid for 5 consecutive years on bindweed-infested ground given intermediate cultivations and plowed just before planting the soybeans and shortly after their harvest, will completely eradicate bindweed.

When 4-inch cultivation was reduced from once a week to once every 2 weeks in an effort to gradually destroy bindweed infestations, bindweed roots left in the soil lost more reserve nutriment, about a fifth more carbohydrates, and more than double the protein, Kansas station investigations show. If cutting is delayed longer, however, reserves generally start to accumulate again. Hence allowing a 2-week interval between cultivations gives best results with least labor.

Chemical weed killers.—Widespread interest in the use of herbicides as labor savers in eliminating hand weeding has greatly intensified California station studies of contact and selective sprays for controlling weeds. Since oils alone are not currently available for roadside weeds, studies have been directed toward a spray consisting of oil fortified with various compounds, among which pentachlorophenol appears most practical. In an emulsion of an oil high in aromatic compounds, the concentration need not exceed 0.5 percent; this would save large quantities of oil. Stove oil has come into wide use as a selective spray on carrots; yet the station found white gasoline to be superior, in that no injury occurred when it was used even in large overdoses.

Borax and sodium chlorate-borax combination, the Montana station reports, can be used to control perennial weeds such as yellow toadflax, St. Johnswort, bindweed, Canada thistle, leafy spurge, quackgrass, Russian knapweed. Whitetop, on the other hand, the most resistant plant tested, was not controlled. Borax was more effective on light porous soils that received precipitation enough to leach the borax into the soil to the depth of the main root system by the time the roots were active in spring. Burning the weed before treatment also increased effectiveness of the chemicals.

REDUCING LOSSES FROM DISEASES AND PESTS

BETTER CONTROL OF PLANT DISEASES

Experiment stations have continued to make substantial advances in research in the field of plant pathology. They have contributed much to our fundamental scientific knowledge about plant diseases on which to base better measures for practical control. They have also made rapid progress in the development and testing of new synthetic fungicides, in the development of crop varieties resistant to

various diseases, and in devising other means for use in dealing with the diverse plant disease problems that confront agriculture. To aid the war effort the stations have tried to place in the farmers' hands the best methods yet developed for plant protection. As a result, American growers are said to make the greatest and most effective use of fungicides of any country in the world in reducing preventable plant disease losses even in the face of the shortages of labor and machinery and of other wartime difficulties.

The following are typical examples of experiment station work in the plant-disease field as reported during the past fiscal year. Much of the accomplishment in this field must be credited to cooperation, formal or informal, between various experiment stations and the Department or between different experiment stations, although such cooperation may not always be mentioned.

Plant disease forecasting saves crops.—In a number of States, experiment station workers each season make systematic field observations or laboratory determinations by which local outbreaks of certain plant diseases can be forecast. Growers are then advised precisely when and where control measures should be applied to get best results. During the war this type of scientific fact finding has resulted in greater efficiency and economy in the production of crops and in greater crop yields. The increase in the potato harvest of at least 2¾ million bushels of potatoes brought about in 1943 in 11 upper Mississippi Valley States through the response of growers to timely local potato late blight warnings is an example. Such warnings were made possible by the cooperative Potato Late Blight Forecasting Service, referred to last year, which was set up by plant pathologists in that area with Federal cooperation. State reports were received weekly, summarized, and redistributed at once by the Iowa station along with forecasts based on a study of the weather and of field evidence of initial infection in the different parts of the region. So successful was the outcome in 1943 that the undertaking was continued in 1944. Resulting grower preparedness is reported to have caused complete exhaustion of the allotted 1944 quotas of sprayers and spray materials in these potato areas, necessitating the purchase from other States of excess vegetable sprayers.

In the Sacramento Valley, sugar-beet producers have been aided in avoiding severe losses from southern blight (*Sclerotium rolfsii*). Samples of soil sent in from different fields before planting time are examined by accurate laboratory methods at the Davis, Calif., station to determine the number of resting bodies of the fungus contained in each sample. Whenever a dangerous degree of contamination is found in a field, the grower is advised not to plant beets in that field. So, too, the Texas station, by mapping out in fields the areas that are seriously infested with phymatotrichum root rot, has made possible the avoidance of contaminated spots in fields selected for planting susceptible nursery stock. Again, studies of winter temperatures in the major eastern sweet corn growing States have made it possible to predict closely the northern limits of serious bacterial wilt outbreaks the following summer. Farmers are then notified that it will be unsafe to grow nonresistant varieties south of these limits.

For some time eight eastern experiment stations have cooperated with the Department in developing an information service on the

sasonal spread of cucumber and muskmelon downy mildew. In this service the South Carolina Edisto substation acts as a clearinghouse. Another valuable contribution to plant disease forecasting has been made by the Oklahoma station. Ways have been worked out there for determining ahead of time the seasons in which seriously damaging attacks of leaf rust of wheat are likely to develop in different States.

Scientific teamwork.—In recent years there has been marked acceleration of the trend among experiment stations toward cooperative attack on various regional and national plant-disease problems in recognition of the advantage that lies in pooling available resources of knowledge, ideas, trained leadership, and specialized equipment, in having access to diverse crops and soil and climatic conditions for the investigations, and in sharing promptly the results obtained by all. Such cooperation is now speeding up the answers to many practical disease problems that plague agriculture. Further instances follow.

Vegetable seed treatment.—In 1943 workers associated with many State stations actively cooperated under the Seed Treatment Research Coordinating Committee of the American Phytopathological Society in continued investigations on vegetable seed treatment which embraced several new objectives. Fungicidal treatments for edible soybean seed as well as for onion seed were included for the first time and with promising results. Nearly a score of different chemicals were tested on seed stocks of different crops under a wide range of climatic and soil conditions. The result proved several new synthetic fungicides to be widely useful in improving stands of plants by cutting down attacks from soil-borne and seed-borne organisms.

Among the most outstanding of the newer seed protectants for many types of crops were Arasan (tetramethylthiuram disulfide), Spergon (tetrachloro-*p*-benzoquinone), and Fermate (ferric dimethyldithiocarbamate). These are discussed separately later in this report. Another material, Catex, developed from an alkaline distillate of southern pine stumps, markedly checked onion smut when used as a drip in the seed row. Onion seed coated heavily with Arasan or Fermate by means of a sticker resisted both onion smut and damping-off. Yellow Cuprocide and the organic mercury dusts continued to prove their value for certain kinds of seeds. Borax was found beneficial for treating sweetpotatoes used for propagation.

A major outgrowth of this cooperative research was the initiation of standard recommendations for protective treatment of certain important vegetable seeds and a movement toward treating vegetable seeds before they are sold in order to insure wider benefits and effectiveness and economy in the use of chemicals. Already several large seed concerns are either pretreating certain vegetable seeds or making a trial of the practice. The favorable results of previous research under the committee led to greater use of seed treatments by farmers and Victory gardeners in 1943 and still more in 1944.

Peanut seed treatment.—During 1943, 10 stations from Virginia through Texas to California put on coordinated tests of peanut seed treatments. Arasan, 2-percent Ceresan, Spergon, and Yellow Cuprocide showed very similar effectiveness in the Eastern States for improving stands and yields. In a west coast test, however, the metallic dusts surpassed the nonmetallic compounds for reasons yet to be explored.

Soybean seed treatment.—Nine States in the upper Mississippi Valley cooperated in the same year in uniform soybean seed treatment tests with five materials. Spergon and Arasan vied for first place, Spergon giving an average stand increase of 27 percent in 3 Northern States, while Arasan did best in the other 6 States, with an average increase of 18 percent in emergence. Root nodulation was not affected where the soil was well supplied with nodule bacteria. In another extensive cooperative soybean seed treatment test in which 13 Central and Eastern States were involved, the benefits were not as large or consistent on the whole, perhaps because the dosages were too low.

Southern corn seed treatment.—A group of experiment station and Federal workers in nine Southern States cooperated in 1943 in testing out the value of corn seed treatment in an area where thorough tests had never been caried through. In general, seed treatment increased seedling stands, although great variation appeared in the different tests due to factors requiring further study. Important information was accumulated in regard to the types of organisms involved in damage to germinating seed and emerging seedlings in different states. The commonest fungus isolated was *Fusarium moniliforme*, the incidence of which was definitely reduced by seed treatment.

Tobacco downy mildew (blue mold) control.—The Department and a number of east coast stations recently cooperated in an investigation of new fungicides for tobacco downy mildew control on which publications were issued during the year. Over 120 organic compounds were tested as possible substitutes for fumigants which, though effective, had not been widely adopted or as substitutes for cuprous oxide spray, which was affected by wartime scarcity. These tests proved Fermate to be highly effective, safe, and convenient, with bismuth subsalicylate, Spergon, and Thiosan also proving meritorious.

Tomato seedling disease problems.—An important project led by the Department, involving cooperation over several years by the New Jersey, Indiana, and Georgia stations, has dealt with tomato diseases, especially those of concern in raising disease-free seedling plants in the South to be set out in commercial tomato fields in the North. Reports from this work indicate that the alternaria leaf spot and stem canker problem may be greatly helped by proper field management of the seedlings, proper timing of removal from the ground, and proper methods of handling and storing prior to setting out. New Improved Ceresan was found highly effective as a suspension for tomato seed treatment. The dip successfully got rid of surface-borne disease-producing fungi and bacteria and gave a little protection against soil-borne organisms. Recent tests of 37 materials by the New Jersey station indicate, however, that the use of New Improved Ceresan as a dust will give just as good seed protection as the dip and avoid the labor, time, and hazard of dipping some 75,000 pounds of tomato seed annually treated in that State.

Soil fumigant research.—Research on soil fumigants has received impetus through appointment by the National Committee on Agricultural Experiment Station Organization and Policy in the fall of 1943 of a committee of leading experiment station scientists to work jointly with a similar committee of the Department with the object of speeding up the investigation of soil fumigants with respect to

their potential value and limitations in the control of root knot and other crop-damaging nematodes, noxious soil-inhabiting fungi, insects, and weeds. Many State stations have volunteered to coordinate their work with that of others under the leadership of this committee. A summary of the results of the first season's experiments is not yet available, as this is written, but early trials indicate that the new synthetic fumigant known as DD, a mixture of dichloropropane and dichloropropylene, which appears to work as well in many open soils as chloropicrin and at considerably lower cost, will be highly effective against root knot nematode.

NEW AND IMPROVED FUNGICIDES

The outstanding performance of a number of newly developed synthetic organic chemicals and combinations in experiments on plant-disease prevention at many stations during the year is especially noteworthy.

Dithane (disodium ethylene bisdithiocarbamate) is among the newest of the synthetic fungicides to be widely tested although it is not commercially available. The Connecticut (State) station, cooperating with the Crop Protection Institute, after testing this material, pronounced it promising against apple scab, potato leaf diseases, black spot and powdery mildew of rose, celery blight, and *Pythium* on pea seeds. It is water soluble, becoming insoluble, practically invisible, and very tenacious on drying. The experiments show that it is safe to apply on foliage but that it starts to run off too soon to build up a heavy coating. Dithane was also found to have insecticidal value.

The Delaware station showed that mixing zinc sulfate and lime at small cost with Dithane tremendously increases its fungicidal ef-effectiveness. This combination surpassed six other sprays tested against early blight of potatoes. It raised the yield to 219 bushels per acre as compared with 182 bushels when bordeaux was used, 154 bushels for Dithane alone, and 87 bushels for unsprayed potatoes. The Florida station also found the Dithane-zinc-lime spray greatly superior to copper fungicides used against potato late blight. In one test it gave a yield of 381 bushels per acre as against 186 bushels for Dithane alone and 94 bushels for unsprayed potatoes. The Texas station got very similar results, and the Pennsylvania station also found it promising for potatoes. Moreover, the Florida station got outstanding results with it as a tomato late blight preventive. The Louisiana station reported young cucumber plants to be very sensitive to this material.

Fermate (ferric dimethyldithiocarbamate).—In extensive tests by many stations in 1943 Fermate, the new organic compound, showed promising effectiveness against a number of important diseases with little or no fungicidal injury on most plants. Compatibility with oil and with nicotine compounds is reported. The Rhode Island station found that it did not reduce photosynthesis like lime-sulfur. Effectiveness against tomato anthracnose was reported by the New Jersey, New York State, and Ohio stations. Tomato early blight control was excellent with Fermate in experiments by the New Jersey, New York State, and West Virginia stations. It can be used either as a dust or spray. It has given superior results in tobacco downy mildew con-

trol according to the Florida, Connecticut, Massachusetts, and North and South Carolina stations, and the Department. For vegetable seed treatments and damping-off of seedlings, the Florida station has found it effective. The Virginia Truck Station used it with success as a dust against eggplant phomopsis blight. The New York State station found it good for bean anthracnose. The Ohio station reports mild foliage injury on carrots, though Fermate controlled leaf blights well. In tests made by the Department bordeaux gave 35 percent control of cranberry field rot at the Cranberry station in New Jersey, while Fermate spray gave 94-percent control.

For apple scab, Fermate has shown exceptional promise in tests by the Rhode Island, New Jersey, Virginia, and Pennsylvania stations. With it the Virginia station obtained excellent control of cedar rust on apple foliage and reported good results with apple bitter rot. In experiments with six spray materials over 2 years, the New Jersey station reports best results with Fermate against sooty blotch and Brooks fruit spot, scab on apple, and fruit russet. The North Carolina station got better results against apple frogeye leaf spot with Fermate than with four other materials but reported lack of effective control for bitter rot or blotch. Promising results with Fermate for cherry leaf spot control were obtained by the Oregon station, while the New York State station reported excellent protection against cherry brown rot and gray mold and ability to help keeping quality on the market, although on light-colored fruit the dark-colored residue is objectionable. The California station got up to 73-percent increase in apricot yields by using Fermate against gray mold and brown rot attack on blossoms and young fruit and found it useful against peach brown rot, rust, and coryneum blight. Fermate proved of doubtful value for walnut bacterial blight control in cooperative Department-Oregon station work. The destructive botrytis blight of tulips was controlled by Fermate at the western Washington station. The New York (Cornell) station found that dipping chrysanthemum cuttings in Fermate controlled septoria leaf spot well, and the California station got good protection against a basal rot of soft green chrysanthemum cuttings by using Fermate dust.

Arasan and Thiosan (tetramethylthiuram disulfide).—These organic sulfur compounds have the same active principle but contain different supplemental substances. Arasan has been one of the leaders among many good compounds for effectiveness in seed treatment tests conducted by a large number of stations. This dust has shown protective value against seed and soil-borne organisms for peanuts, soybeans, onion, segmented sugar-beet seed, flax, and many vegetable seeds. In addition, the Minnesota station found that the germination of frost-injured and moldy soybean seed was vigorous and normal instead of weak when treated with Arasan or certain other fungicides. Thiosan is reported by the Florida station and the North Carolina station to be good as a soil drench for celery and lettuce beds, respectively, against damping-off. Several States with the Department found it effective against tobacco downy mildew. Scurf and stem rot were markedly controlled at the New Jersey station by dipping sweetpotato sprouts in Thiosan, and without the sprout injury and retardation often caused by mercurials.

Spergon (tetrachloro-p-benzoquinone). — Introduced at first mainly as a seed protectant, Spergon continues to show excellent fungi-

cidal properties with little or no injury, in tests by a very large number of experiment stations. In the 1943 tests it proved to be among the best seed-treatment dusts for many vegetables, corn, soybeans, peanuts, segmented sugar-beet seed, etc. Cooperative Federal-State station tests have also shown Spergon to be of value against tobacco blue mold. The Florida station got good results in controlling cabbage downy mildew by dusting or spraying the plant beds with Spergon two or three times a week. Tomatoes sprayed with Spergon for alternaria blight in New York State station tests yielded at the rate of over 15 tons per acre, a gain of 4 tons over unsprayed plants. It helped to suppress damping-off in celery seedbeds, also, when used as a drench in Florida station tests.

Sinox and Elgetol (sodium dinitro-o-cresylate).—To forestall heavy losses of tubers from late blight rot, the Maine station found Sinox very promising. Applied ahead of digging time, it kills the potato tops and prevents further production of blight spores and infection of the tubers. Wisconsin station experiments over several years prove that spraying the old leaves on the apple orchard floor with Elgetol, just as the winter buds start to break, materially aids the apple scab-control program by largely destroying this source of primary infections. The California station found Elgetol dissolved in methyl alcohol effective when used for painting crown galls of orchard trees to kill these cancerous growths. Applied on peach trees in the late dormant stage, Elgetol materially reduced leaf curl and coryneum blight in Idaho station tests.

Tetrachloroquinone.—This synthetic compound was found effective at the California Citrus station as a spray against brown rot of citrus, a disease which has caused great damage by producing gummosis of trunks as well as rot of fruit. It also improved stands of soybeans when used in seed-treatment tests at the Delaware station.

Exploratory research in synthetic fungicides.—A number of experiment stations are engaged in exploring the field of synthetic organic compounds. The objective is to find or create chemical combinations that are more effective, less injurious, more convenient, and less expensive than the old familiar fungicides. In this work station plant pathologists enjoy the close cooperation of industrial chemists who can synthesize proposed new combinations or improve old ones.

The Rhode Island station, for example, reports encouraging progress in a search for superior plant-protecting or disease-eradicating properties among commercially available or experimentally synthesized members of the following chemical series: Quaternary ammonium halides, cationic phenylmercuri nitrilo compounds, imidines, betaines, heterocyclic nitrogen (pyridinium, quinolinium, acridinium) compounds, chlorophenyl methanes, and isoquinolinium halides. The preliminary results indicate that certain members of these groups may have high fungicidal value combined with invisibility when used, in some cases, as dilute as one part in a million. Some of these materials appear safe on plant tissues even in concentrated solutions. Some show high wetting power, compatibility with mineral oils and arsenicals, and stability under a wide range of temperatures and in strongly acid or alkaline solutions. A large number of them can be inexpensively synthesized from byproducts of the coal industry.

Most of these synthetics were still in the experimental stage, but about 20 experiment stations were cooperating informally with the Rhode Island station in testing certain of them in order to learn more in regard to their possibilities and limitations for plant-disease control. Tests with phenylmercuri nitrilo triethanol lactate (Puratized N5X), diluted 1 to 10,000, showed it to be highly effective for apple-scab control and apparently noninjurious, in Rhode Island station tests. Lauryl isoquinolinium bromide and lauryl pyridinium bromide were nearly as effective against scab and also killed aphids. Certain of these compounds appeared promising for treating cut seed potatoes without injury to sprouting.

The Mississippi station reported some promise in a new product combining aromatic phenylphenols and hydroxynitrocresols. Results from its use for disinfecting sweetpotato seed pieces were distinctly encouraging. The California station showed that the synthetic dyes known as Brilliant Green and Malachite Green can be used to disinfect tomato seed from the bacterial canker organism without injury to germination.

A number of volatile synthetics are being widely tested, as already mentioned, for their usefulness in fumigating soil. Chloropicrin has proved its value in 7 years of experimental work by Texas station workers. When injected into the soil and protected against rapid dissipation, it has been highly effective against the root knot and meadow nematodes, tomato wilt, southern blight, damping-off fungi, and weeds. Its cost, however, appears to limit its practical use to high-value crops, seedbeds, greenhouses, home gardens, etc. The North Carolina station found it promising against root knot in seedbeds. The Department and Georgia Coastal Plain station have also proved the value of chloropicrin, when applied under proper conditions, in reducing root knot infection in fields of tomato plants grown for certification and has shown the practicability of using it for preliminary "spot" treatment of watermelon hills to cut down root knot damage. The New Mexico station found it effective against the pink root disease of onions. The South Carolina station used it successfully and inexpensively to eradicate contaminating decay fungi from empty sweetpotato-storage rooms in 24 hours.

As previously indicated DD, a relatively cheap synthetic byproduct composed of dichloropropane and dichloropropylene, has been found by the Mississippi, Hawaii, and other stations to be apparently equal to chloropicrin as a soil fumigant against nematodes. The Florida station found it promising against root knot but not for the rhizoctonia fungus. The New York (Cornell) station found nematodes well controlled by fall treatment of greenhouse soil with a triple combination of methyl bromide, ethylene dichloride and carbon tetrachloride which cost less than chloropicrin or other fumigant combinations tested. Damping-off of vegetable seedlings was prevented in Florida station tests by treating rhizoctonia-infested soil with chloropicrin or methyl bromide.

Plant chemotherapy.—Although failure has followed many past efforts to supply to the sap of plants substances that will cure infectious diseases, renewed attempts are being made which take advantage of newer scientific knowledge. The Connecticut (State) station reports interesting experimental indications that when watered on the soil the

new synthetic Dithane may be absorbed and retard the progress of the Dutch elm disease in affected stems. Infection from artificially applied tomato wilt fusarium spores was prevented for a protracted period by dipping the tomato seedlings before planting in extremely dilute solutions of 8-hydroxyquinoline in research at the same station. Growth of the fungus is thought probably to be prevented by the action of this type of chemical in depriving the fungus of required trace elements like zinc, copper, etc., by precipitating them as chelate inner salts. At 1-10,000 dilution the chemical completely stopped all growth in cultures of the fungi that cause the elm disease, potato wilt, tomato wilt, and blue mold. Using only one-half part per million, workers in Department-Texas station research prevented growth of the phymatotrichum root rot fungus with this material.

The Virginia station drew attention to evidence that application of sufficient potash to the soil renders corn less subject to damage from bacterial wilt by preventing too much nitrate from accumulating in the water-conducting tubes of the plant, a condition that favors multiplication of the germs in these tubes. This may explain why the Texas station and others have found it essential to supply cotton plants with sufficient potash to maintain or increase resistance to damage from the fusarium wilt fungus, which also grows in the water vessels of the plant. The Vermont station found clear evidence that under certain special conditions treatment of a soil with borax may prevent alternaria blight attack on potato foliage. Investigations such as these point to the need for persistent and painstaking research to lay a sound scientific basis for the development of the practical possibilities that may lie in the field of plant chemotherapy.

Synergism.—Experiment station work has recently opened up extremely valuable possibilities for intensifying the fungicidal power of certain spray materials by adding other materials, which, though perhaps of little or no value themselves for disease control, in some way work with these chemicals to magnify or measurably prolong their effective action. This is called synergism. The West Virginia station, for example, discovered that a little soybean flour greatly increased the solubility and effectiveness of cuprous oxide against the ubiquitous damping-off fungus of the soil, *Pythium debaryanum.* Too much soybean flour, however, destroyed the toxicity of the cuprous oxide for *Pythium.*

The Connecticut (State), Nebraska, and Delaware stations, and other stations have recently announced important possibilities and limitations in synergistic combinations. For example, when 1 part of cuprous oxide was diluted with 3 parts of sulfur the effectiveness of the copper against tipburn of potato foliage was improved about 14 times. When this combination was tested against celery leaf spot, however, no such booster effect took place. The addition of inexpensive zinc sulfate and lime to certain sprays has been found to increase their crop protective values. Alone, Dithane gave 42-percent control of potato early blight as observed in mid-October. With the zinc-lime addition 92-percent control resulted. Copper oxychloride (Compound A) alone gave 58-percent control in the same investigation, but with zinc and lime it gave 82-percent control. Further exploration of synergistic possibilities is going forward in the interest of better and cheaper spray protection for crops.

REDUCING LOSSES FROM PESTS

Sweetclover weevil.—Sweetclover weevil has become injurious and widespread in the North Central States, feeding as an adult on the leaves and new growth of the sweetclover plant. Complete defoliation of plants in early spring is likely to occur, often resulting in the death of small plants.

This insect is easily killed by sulfur containing 0.8 percent of dinitro-*o*'-cyclohexylphenol (DN), according to the Wisconsin station and the Department (BEPQ). Several insecticidal dusts were tried, these being applied at a rate of 10 pounds per acre. In one plot a 96.6-percent kill was obtained with DN sulfur dust. Of the other dusts, undiluted calcium arsenate appeared best, the kill being about 50 percent, while barium fluosilicate showed some control under Wisconsin conditions. Rotenone 0.75 percent in talc; rotenone 0.75 percent and nicotine 2 percent in pyrophyllite; rotenone 0.75 percent in sulfur; and pyrethrum (0.2 percent pyrethrins in talc) appeared worthless.

The adults have been found by the North Dakota station to attack one variety of sweetclover as readily as another. The degree of injury is correlated with the stand, however, and the poorer the stand, the greater the injury. As a result, the station is now recommending a sweetclover variety which produces a large amount of foliage early in the season. Observations in several areas showed that the Great Plains toad took a tremendous toll of the sweetclover weevil population during the summer of 1943.

Alfalfa butterfly.—The alfalfa butterfly is the most important alfalfa pest in the Southwestern States and has been difficult to control, because contact insecticides have proved ineffective or too expensive and poisons offer a hazard to livestock. Recent research conducted by the California station on the control of this pest indicates that sulfur offers considerable promise. Excellent results were obtained by treating alfalfa at the 8-inch height with 325-mesh dusting sulfur at 75 pounds per acre. This left no poisonous residue, and the sulfur did not affect either the wilt disease or the beneficial parasites that account for some mortality of this pest. Further research is needed on dosage, palatability of dusted hay, and timing of applications.

Alfalfa plant bug.—An introduced species of alfalfa plant bug *Adelphocoris lineolatus* (Goeze) first recorded in Minnesota in 1933, has become State-wide in distribution on alfalfa and sweetclover. Reduction of alfalfa seed yields in Minnesota since the early 1930's has coincided with the spread of this insect pest, which prevents seed production by feeding on buds, flowers, and seed pods, according to findings of the Minnesota station. Thorough burning of alfalfa fields in the fall before the mirids became active effectively reduced populations of this insect. Populations were reduced only slightly where burning was not thorough. Cultivation was not so effective as burning. Tests on one-half-acre plots with pyrethrum dust and sulfur indicated that pyrethrum was more effective than sulfur, but seed yields in treated plots were not any greater than those in nontreated plots.

Plant bugs.—Injury to bluegrass results in reduced seed production and, when abundant, can prevent development of seed in Kentucky bluegrass. The Kentucky station has found that two species, *Miris dolobratus* L. and *Amblytylus nasutus* Kirsch., are involved.

Seed from infested plants weighed less and did not germinate so readily as that from noninfested plants. Pastures heavily grazed in the summer and fall have smaller populations of plant bugs the following year than those only lightly pastured.

Southwestern corn borer.—The Southwestern corn borer occurs in 51 Kansas counties, according to recent studies by the Kansas station. Injury is produced by the borers feeding on the leaves and on or about the main bud within the shorl, boring in the stalk or in the shanks and ears, and girdling or reaming the stalks from within causing them to break over or fall to the ground. Considerable losses are due to fallen stalks, since the ears are difficult to harvest, spoil readily, and are exposed to destruction by rodents. Sorghum is much less severely infested and injured than corn. Limited experimental data indicate that substitution of sorghums for corn, early planting of corn, late-fall treatment of stalks and stubble to expose overwintering larvae during the winter, deep plowing of stubble, and low cutting of stalks are practices which might contribute to the control of this pest in Kansas.

Chinch bug barriers.—Chinch bug barriers, made of dinitro compounds as substitutes for war-short creosote, proved satisfactory in studies by the Iowa station in field trials of 2, 4, 8, and 12 percent of 4, 6-dinitro-*o*-cresol, dinitro-*o*-secondary butylphenol, and dinitro-*o* cyclohexylphenol in pyrophyllite, used both with and without 5 percent added mineral oil. All three substances proved about equally effective, and the 2- and 4-percent dusts about as much so as the higher concentrations. Properly constructed barriers of 8 percent dinitro-*o*-cresol were effective when used at the rate of 4, 8, and 16 ounces per rod. In laboratory tests to determine the lower limits of effective dilution, all three materials proved so toxic that a large percentage of the bugs were killed by merely walking across the thin layer of dilute dust. It appears that any one of these compounds may be used successfully as a barrier and that price as well as speed of action should be considered in the final selection.

Rice stink bugs.—Rice stink bugs cause a reduction in the rice crop and injure quality of rice to a material degree. They have not been effectively controlled up to the present time, but the Louisiana station has found that a combination of nicotine and β, β'-dithiocyanoethyl ether kills the nymphs and adults in from 15 to 30 minutes. The same chemical was also found to kill a number of other insects such as the sweetpotato weevil and aphids that have not been well controlled by any one insecticide. The new combination may also prove a substitute for derris and pyrethrum on at least certain of the fall, winter, and spring leafy vegetables, according to preliminary observations.

Corn earworm.—Damage to ear tips of sweet corn by corn earworm often may be avoided during seasons of moderate to light infestations of this insect by planting so that the silking period coincides with that of most of the fields in a community, according to the Kansas station. Thus, the population of ovipositing moths and resulting eggs are greatly dispersed. Planting dates usually satisfactory for escaping egg deposition are for late-maturing varieties, as Stowell Evergreen and Country Gentleman, about May 1; medium-season varieites, as Golden Cross Bantam and Ioana, after May 12; and short-growing-period varieties, as Howling Mob, after May 20. Stout string tied around the ear about one-half inch from the tip reduced infestation of

the remainder of the ear to a negligible amount. This treatment has been used successfully by market and Victory gardeners.

European corn borers.—European corn borers are a serious menace to corn production in the Middle West. In preliminary tests with a stalk pulverizer attachment for mechanical corn pickers, the Indiana station found that 95.3 percent of the corn borer larvae were killed by the pulverizer when heavy long hammers, rotating at about 1,700 revolutions per minute, were used. Most of the larvae which seemed to be alive after passing through the pulverizer died within a period of 10 days. Various weights and lengths of hammers were tested to determine their effectiveness and serviceability under field conditions. The pulverized stalks can be plowed under, disked into the soil, or collected for bedding.

Potato flea beetles.—Potato flea beetles were effectively controlled in Nebraska station experiments by early and frequent applications of cryolite-sulfur or barium fluosilicate-sulfur dust or zinc arsenite sprays. Dusts have been as effective as sprays. Satisfactory control in late plantings by insecticides have been extremely difficult where earlier fields are nearby. The elimination of early plantings is therefore desirable. Final insecticide applications should be made before the vines close the rows.

Aphids.—On Long Island potatoes, aphids, particularly the potato aphid, which attack the crop for a period of 3 weeks beginning in late June and cause serious injury, were controlled with nicotine applied as a spray, dust, or vapor by the New York (Cornell) station. While a single application of nicotine vapor was sufficient for adequate control, more than one application of the spray or dust was sometimes necessary to prevent increase of the aphids. Spray applications should be applied previous to peak populations.

Tomato russet mite.—By far the most serious arthropod pest of the tomato is the tomato russet mite. In cooperative studies by the California station and the California Department of Agriculture, straight dusting sulfur (325-mesh) gave practically 100-percent control with no burning of the plants. The mite reproduces on tomatoes, petunias, potatoes, and other *Solanum* spp. tomatillo, and *Datura* sp., and develops most profusely and destructively on round red-fruiting tomato varieties. The typical russeting first appears on the lower part of the tomato stalk, spreads upward, and is finally accompanied by cracking of the main stalk and browning of the leaves, the fruit being attacked in the most severe cases. The principal commercial injury is from the loss of leaves and consequent sunburning of the lower fruits.

Beet leafhopper.—Profitable tomato production has been made possible, even in seasons of severe beet leafhopper abundance, through research studies of the Department and the Utah station. As previously reported, this station has found that double-hill planting and the use of cheesecloth covers will permit economic production during such years. Spring and fall surveys of beet leafhopper abundance and host plant conditions give the farmer advance information that permits him to increase plantings during years of anticipated leafhopper scarcity and to use double-hill planting or gauze covers when severe injury is anticipated.

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Turnip aphid.—Widely distributed in North America the turnip aphid is the major pest of turnips, mustard, and radishes in the South. Under Louisiana conditions the Louisiana station and the Department (BEPQ) obtained effective control with a dust mixture containing 1 percent rotenone with equal parts of finely ground tobacco dust and 300-mesh dusting sulfur. From 16 to 46 generations occur annually, and the number of young produced by each female ranged up to 123. There were from three to five nymphal molts. The production of winged individuals was closely associated with the quantity of good material in the host plant or the ability of the individuals to obtain sufficient food for optimum growth.

Onion thrips.—A spray composed of tartar emetic and brown sugar used for the control of onion thrips resulted in a net return of $275 per acre on an investment of $8 per acre, according to the New Jersey station. Two applications of this spray gave an increase of eighty-one 50-pound bags of onions over the yield on untreated check plots. With onions at $3.50 per bag on the farm, this represented an extra return of $283.50 per acre, from which was subtracted $8 per acre for labor and spray materials.

Definite advances have been made by the Colorado station, cooperating with the Department, in developing a thrips-resistant Mountain Danvers onion which also carries desirable bulb shape, type, color, and uniformity, and possesses superior dehydration and storage qualities. Progress is being made, also, in developing a Sweet Spanish variety more resistant to purple blotch and to pink root than other varieties. Development of insect- and disease-resistant varieties would reduce losses in yield that now run into several hundred thousand dollars annually.

A six-row, 50-gallon, self-propelled sprayer was used in experiments by the New York (Cornell) station for onion thrips control. Six applications reduced thrips populations from 66 per plant to 12 per plant, while three applications resulted in a reduction of from 70 to 33 per plant. The volume of spray applied was varied by using different sizes of disks. Onions sprayed with number 3 disks had 12 thrips per plant; those sprayed with number 2½ disks had 23 thrips; while those not sprayed averaged 55 thrips. Counts of thrips per sprayed plant averaged 20 and 22, respectively, while nonsprayed plants averaged 60 when sprays were applied at 100 and 300 pounds pressure.

Edible European snail.—Imported into California about a half century ago, the edible European snail, *Helix aspera*, has become one of the most serious pests of lemons and oranges in certain coastal areas. It is also destructive to vegetables, especially in northern California. The snails are omnivorous feeders and eat the bark, leaves, and fruit of citrus trees. Of some 50 materials tested by the California station a spray of tartar emetic gave effective control. Snail activity is associated with the presence of moisture; hence the spray must be applied when they are actively feeding in order to obtain effective kill.

MORE EFFICIENT INSECTICIDES AND SUBSTITUTES

Control of plant pests.—Effective pest control necessitates proper plant coverage, proper timing, and efficient use of materials. During

the war period means of "stretching" insecticides has become a subject of paramount importance. Station entomologists have been cooperating on a series of experiments involving techniques for the application of sprays and dusts. Previous studies, particularly by the Wisconsin and Connecticut (State) stations, have shown that the toxicity of certain dusts is markedly affected by the type of material used as diluent, usually termed the "inert" carrier.

Similar results with other toxic materials have been shown by further field trials of the Connecticut (State) station.

Nicotine bentonite was mixed with clay and with pyrophyllite for use against the European corn borer. Approximately 5-percent nicotine was required in the clay mixture to equal the effectiveness of 3 percent nicotine in the pyrophyllite mixture. Pyrophyllite, however, proved only slightly superior to clay when mixed with cryolite and used for Mexican bean beetle control. A dust of free nicotine prepared from a powdered concentrate was much more effective with pyrophyllite as a diluent than with hydrated lime. In fact, 1-percent nicotine in the pyrophyllite mixture was as effective as 10-percent nicotine in the hydrated lime, when used for cabbage aphid control.

During the past few years many materials have been evaluated by the State stations in an attempt to find promising insecticides for the protection of crop plants, man, and animals. Some of the materials tested are synthetics recently developed by industry or by State station and Department workers, while others have been obtained from new plant sources, both native and imported.

One of the proprietary compounds, DDT, or dichlorodiphenyl trichloroethane, has been used experimentally by a number of stations both as a spray and as a dust. For example, both the California and the New Jersey stations found this material effective against the oriental fruit moth when applied as a spray. The New Jersey station found a DDT dust more toxic to roaches than sodium fluoride, derris, or pyrethrum dusts. Sprays of this material offer promise for the control of California red scale, according to results from the California station. Preliminiary experiments by the Maine station showed DDT toxic to black army cutworm larvae on blueberry land.

Spraying.—Effective and timely spraying of orchards has been difficult during the emergency period because of labor shortage. To reduce the number of skilled spray operators required, the Delaware station has been working on a new type of spray equipment that throws strong jets of spray from nozzles set at different heights on a hollow-steel mast rising from the spray truck. The direction in which the nozzle point can be changed simultaneously by a hand-operated lever so the spray will sweep the trees from different angles in passing. For covering the top and interior of the tree, this machine surpassed both the "Speed Sprayer" with its air propellor blast and a modern power sprayer with two eight-nozzle brooms operated at different heights. This machine proved speedy and required a minimum of skill and only one operator besides the driver.

Saving insecticide.—Less insecticide than formerly was necessary for effective coverage is used by a spray duster developed by the California station and now being manufactured for commercial use. The air blast is delivered by a squirrel-cage type of fan, and the machine is adjusted so that adequate coverage is obtained with as small an amount of spray liquid as 1 gallon per tree.

Marc.—Marc, the residue remaining after the pyrethrins have been extracted from pyrethrum flowers, is being studied from an insecticidal viewpoint by the California station because of the shortage of pyrethrum for insect control. This material was found to have definite possibilities in the control of cankerworm on apricots. A large quantity is available.

Better fly spray.—A spray developed by the Oklahoma station, when used on dairy cows, apparently was somewhat repellent to horn flies 10½ hours after spraying and stable flies up to 4 or 5 hours. This spray was equal or superior to a number of sprays now on the market. DDT, one of the toxic ingredients, is not now available, but wartime development of this new insecticide is expected to increase the efficiency of fly sprays greatly after the war. Approximately 1 tablespoon of spray was used per cow. The period of repellency slightly decreased when the amount of spray was halved and slightly increased when it was doubled.

New sources for rotenone.—Several experiment stations have investigated new sources for rotenone. For example, scarcity of rotenone led the Hawaii station to explore the possibility of growing the wild rotenone-containing plant called ahuhu (*Tephrosia* spp., related to the devil's shoestring (*T. virginiana*) of the United States) by the natives, who have used it to stupefy fish. This plant was found to make rapid and vigorous growth and to provide a succession of pickings when irrigated. These studies thus far have shown that there is a possibility of developing a local source of rotenone in case of necessity.

A possible substitute insecticide for rotenone, the supply of which has been limited by the war, is being investigated at the Oklahoma station, and production of its source developed. The toxic principle occurs in a brownish, viscous substance in small, blisterlike pustules on the seed pod of *Amorpha fruticosa* ("cat willow" or "river locust"), which grows wild over much of the central United States and is especially abundant along the eastern borders of the High Plains grasslands. The toxic principle apparently is not a rotenoid but gives similar biological effects. It has shown insecticidal value for the tent caterpillar and the spotted cucumber beetle. Because the toxic substance occurs on the seeds instead of in the roots (as with rotenone sources), the insecticide may be obtained without destroying the plant. Individual plants vary greatly in the quantity of toxin produced; therefore, efforts are being made to select or breed a high-yielding strain. Other research is directed at further determination of the insect species to which the substance is toxic, its chemical nature, and methods of cultivation and harvesting the plant in which it is found. This plant probably can be harvested by combine if developed commercially.

Rotenone in yam bean.—Occurrence of rotenone and other toxic materials in the yam bean is of particular interest since this plant has been suggested as a source of insecticide material to supplement the usual rotenone-bearing insecticides. Research conducted by the New York State station has shown the rotenone content of the beans to be about 0.1 percent. Rotenone, however, does not account entirely for the toxicity of yam beans since a number of other compounds of unknown constitution have been isolated, some showing definite toxicity

to insects. These compounds are being studied by the New York State station.

Repellent materials.—Repellents for the protection of man from insect annoyances have been studied by the New Jersey station for several years. With the outbreak of the war, its services were offered to the Department (BEPQ), the agency designated to carry on a research program for repellents for military use. The work was started early in 1942. By midsummer, "Formula No. 612," a solution developed at the New Jersey station, was approved for use by the Army. This repellent is many times more effective than the best of its predecessors. It has no unpleasant odor, is not injurious to man or materials, stands up under severe storage conditions, and is inexpensive to manufacture. "Formula No. 612" is now being manufactured commercially for use by the armed forces.

Natural crude cryolite.—Natural crude cryolite (70 to 75 percent cryolite) is an acceptable substitute for the refined product (90 percent cryolite) for codling moth control where lead arsenate is not readily obtainable and the supply of refined cryolite is limited, according to the Washington station.

Cryolite.—Cryolite, shown by the Tennessee station to have exceptional value for insect control, has become particularly useful for the protection of vegetable crops. An example of the rapidity with which the use of cryolite as an insecticide has spread is shown in Hawaii, where local vegetable production is important in wartime. Cryolite was imported first in 1940, 3,615 pounds of it. By 1943, over 60,000 pounds were brought into the islands, according to the Hawaii station. This material is now considered the most valuable single insecticide for vegetables available in Hawaii at the present time.

Dusting sulfur.—Use of dusting sulfur in psyllid control, as developed by the Colorado station, made potato growing in Victory Gardens and small acreages possible for the first time in the State; thousands of bushels were so produced in 1943, and more were grown in 1944. Use of liquid lime-sulfur has been reduced because of container and labor shortage.

Lead arsenate injury.—Lead arsenate injury to peach foliage has been a serious problem in New Jersey orchards in recent years. Although lime added to spray mixtures containing lead arsenate lessens this injury, many cases have been observed even when this practice was followed. This year a new approach was tried by the New Jersey station. Lime was included, not only in the sprays containing lead arsenate, but also in the next following spray containing no lead arsenate. By this additional lime, foliage injury was largely overcome. Apparently, under some conditions, the lime loses its protective value before the arsenic is weathered off, and the subsequent addition of fresh lime extends the protective period.

Fumigating greenhouse soil.—Nicotine drenches or nicotine powders applied to greenhouse soil at the base of small tomato plants kill or repel symphilids and millipedes feeding there, according to recent studies by the Pennsylvania station. Nicotine pressure fumigators directed against the bed soil in evening tests killed many millipedes on the soil. Carbon disulfide, however, should not be applied when the soil is wet or cold or if it is not loose. At least a week must be allowed after using this fumigant before planting tomatoes.

Insecticide dust.—A dust containing 10 percent nicotine was made by the Kentucky station from tobacco extracted with solvent, dried, and finely ground. This dust was diluted to 2 percent nicotine content by the addition of 1 part of hydrated lime and 3 parts of pyrophyllite to 1 part of the 10-percent dust. In laboratory tests against plant lice the 2-percent dust gave 93.2- to 100-percent mortality in 24 hours. Lime in the mixture was found necessary to produce maximum results. A 1-percent dust of similar formula gave poor control. In comparative tests, 0.5-percent rotenone dust acted slowly and gave less satisfactory results than the 2-percent nicotine dust having lime in the formula.

PRODUCING NEEDED SUPPLIES OF ANIMAL PRODUCTS

Production statistics pay tribute to the efforts of livestock and poultry farmers of the United States in meeting the war-production goals. Total meat production increased annually from 19.5 billion pounds in 1941 to 24.1 billion pounds in 1943, while the 1944 forecast as of July 1 was 25 billion pounds. Total egg production increased from 41.7 billion eggs in 1941 to nearly 54 billion in 1943, and production during the first half of 1944 ran 7 percent ahead of the corresponding period in 1943. Milk production increased from 115.5 billion pounds in 1941 to 118.2 billion pounds in 1943, and slight additional gains were registered during the first half of 1944.

The attainment of such production records in the face of critical shortages of labor, farm equipment, and feed supplies has been possible not only because of the unusual efforts of farmers but also because of the reliable information available to them on livestock feeding, breeding, and management practices based upon years of scientific research by the State agricultural experiment stations. The experiment stations in the various States have continued their efforts in this field as typified by the following examples of results accomplished or released during 1944.

MORE AND BETTER FEED FROM FORAGE CROPS

Because of the marked increases in grain-consuming animal units on farms during the past 2 years and a consequent reduction in the available supply of feed grains and byproduct feeds per animal, the maximum utilization of pasture hay and silage in animal production has assumed utmost significance. Research findings have pointed the way to securing increased yields and higher nutritive value in forage crops, with greater dependence on them as sources of nutrients for all types of farm animals.

MAXIMUM USE OF PASTURES AND RANGE

Under this broad field new information has been made available on better pasture and range management, the comparative composition and nutritive value of different forage plants, and effective ways of utilizing pastures for different classes of farm animals.

Pasture and range management.—Reseeded abandoned croplands in the dry-land area of the State produced half again as much beef per acre as native range in grazing tests at the Colorado station.

Mowing sagebrush increased beef production of yearling steers 123 percent per acre (26 percent per head) as compared with the production on unmowed pastures in 1943 summer grazing trials made by the Oklahoma station in cooperation with the Department. The stocking capacity of the mowed pastures was nearly twice that of the unmowed pastures, and the gain per head was 384 and 305 pounds, respectively.

At the Louisiana station a group of grade beef cows, rotated between two pastures which were mowed regularly and from which hay was put up for wintering, weaned 91.7 percent of their calves, valued at an average of $56.94 per cow. A similar group of cows on weedy pastures, not mowed and with no hay put up, weaned 82.8 percent of their calves, valued at $42.39 per cow.

In estimating the carrying capacity of range lands the usual practice is to count two lambs as the equivalent of one ewe. Nevada station studies have shown that because of increased feed consumption by the ewe after lambing her forage requirements plus that of her single lamb, equal the feed consumed by two mature sheep. Accordingly, if adequate feed is to be provided for continuous rate of growth of lambs a mature-sheep ration must be provided for each single lamb from the day of its birth and 1½ mature-sheep rations for twin lambs.

Comparative value of pastures.—The use of grass-legume mixtures by the Washington station in studies on beef cattle production has shown that nearly three times as many pounds of beef per acre were produced with grass-legume mixtures as were secured from pure grass pastures. For a 2-year period the pure stands of smooth bromegrass and standard-crested wheatgrass averaged 87 pounds of beef per acre, while four different grass-legume mixtures involving these grasses with alfalfa or sweetclover averaged 224 pounds of beef per acre. This outstanding increase in pasture productivity due to the presence of alfalfa or sweetclover in the pasture flora represents an effective and economical method of increasing feed supplies.

A series of grazing experiments with three common grasses, *Paspalum hartwegianum*, Pará grass (*Panicum barbinode*), and Napier grass (*Pennisetum purpureum*), at the Puerto Rico University station gave evidence that Pará grass is highly promising as a pasture crop in the north coastal area. Over a 6-month period this grass produced 119 percent more beef per acre than the *Paspalum* and 29 percent more than the Napier grass.

Pasture for beef production.—Pastures may be used effectively at varying degrees of intensity in the production of beef as shown by the New York (Cornell) station. Steers averaging 630 pounds gained 182 pounds per head in 132 days on about 1 acre per head of well-improved pasture. They produced carcasses grading "low-good," and the beef was readily acceptable to the local beef trade. Another lot pastured for 69 days, followed by 85 days on a fattening ration, gained an average of 256 pounds and graded "top-good." A third lot on good pasture for 112 days with ground corn ad libitum gained an average of 236 pounds per head and graded "low-choice." The remaining lot, fed a dry-lot ration without pasture, gained an average of 230 pounds per steer and produced the highest grade of beef, but the grass-fattened steers made the highest net returns. The feeding

of grain throughout the grazing season seemed most feasible where the area for grazing was limited.

Year-round grazing of beef cows on bluestem range proved practical at the Oklahoma station. Comparing two methods of using bluestem grass for wintering beef cows, one lot grazed 10 acres per head throughout the year while another lot used 7 acres for summer grazing and the hay from 1.22 acres during the winter. Both groups wintered satisfactorily, but it cost $4.65 more per head to winter the hay-fed group.

Steers on sweetclover or Sudan grass pasture required slightly less corn and considerably less alfalfa hay per unit of gain than dry-lot-fed steers in two 140-day comparative feeding tests at the Nebraska station. Pasturing these crops replaced 27 pounds of corn and about 200 pounds of alfalfa hay per 100 pounds of live-weight gain. The dry-lot steers, however, were better finished in both trials than those finished on pasture.

Roughages for dairy cows.—Results of Hawaii station studies substantiate earlier findings and demonstrate that considerable saving of soybean meal can be made by using koa haole (*Leucaena glauca*) as the roughage for milking cows. Cows grazed on koa haole areas and fed a concentrate mixture with 5.43 percent digestible crude protein were compared with the same cows when fed Napier grass as a soiling crop supplemented with an 11.25 percent digestible crude protein content concentrate mixture. During 3 weeks' grazing on koa haole the cows averaged 26.47 pounds of milk daily, while during 2 weeks prior to and 2 weeks after grazing they averaged 24.96 pounds. Concentrate consumption averaged 15.6 pounds daily with each roughage. Because of the lower soybean meal content of the concentrate ration fed with koa haole this resulted in a saving of 2.61 pounds of soybean meal per cow per day.

Another experiment at the Hawaii station compared fresh pineapple tops, or crowns, with Napier grass as a feed for dairy cows. On the basis of chemical composition and in a feeding test with milking cows in which these materials were fed in chopped form as the only roughage, the pineapple tops compared favorably with the green Napier grass. The potential supply of pineapple tops in Hawaii may approximate 40,000 tons annually, at present largely unused.

Wheat for sheep.—Ewes on abundant wheat pasture but with no extra feed produced more gain on their lambs than did well-fed ewes in dry lot at the Oklahoma station. The lambs in dry lot ate approximately 50 percent more feed. Medium rather than high levels of grain feeding were more practical for ewes with lambs in dry lot. The lambs relished Atlas sorgo grain, but it took one-third more sorgo than corn to make the same gain.

Ranges for poultry.—Considerable saving in concentrate feeds may be made by providing suitable ranges for chickens and turkeys.

In an experiment on poultry ranges at the New Jersey station birds reared on ranges showed a considerable saving in feed, particularly in mash consumption, as compared with those reared in confinement. The most efficient weight gains were made by the group on a range planted to Kentucky bluegrass, Canada bluegrass, redtop, and red fescue. A mixture of red clover, alfalfa, Ladino clover, and birdsfoot trefoil proved least efficient of the four ranges tested. Although chickens are not believed to have any sense of taste, it is

apparent from this work that some factor causes them to exhibit marked preferences. Redtop, for example, seemed to be preferred over all other species. Red clover, on the other hand, was hardly eaten at all.

Comparison was made of spring oats; a mixture of ryegrass, Korean lespedeza, and Kobe lespedeza; alfalfa; and bare range for growing pullets at the Tennessee station. The pastured pullets were more uniform in size, pigmentation, and condition of the feathers in each of the 3 years. The average mortality was 9.5 percent for pullets on pasture and 13 percent for those on the bare range. The total feed consumption was about the same with and without pasture, but the proportion of mash was greater when no pasture was available. Of the three pasture groups, alfalfa proved of greatest value in furnishing continuous green feed and producing superior pullets.

Providing growing turkeys with succulent green feed as pasture resulted in a feed saving of 7.2 percent in trials at the Washington station. When the kind of feed consumed, feed efficiency, and mortality were considered, birds reared on pastures gave an increased return over feed cost of 55 cents per bird, or 12.1 percent greater than those reared on the bare lot. Preliminary results indicate that annual crops are just as suitable for turkey pasture as alfalfa.

MAKING AND USING SILAGE

The preservation of feed crops by ensiling has been greatly expanded in recent years with the development of satisfactory methods for preparing silage from grasses, legumes, and other plant material normally low in sugar. In view of current shortages of molasses and phosphoric acid, the most important preservatives for making grass and legume silages, new combinations of crops which can be ensiled without preservatives are of particular interest.

Silage from various crops.—A silage prepared from a 50–50 mixture of alfalfa and *Lespedeza sericea* without preservative by the Tennessee station resulted in a satisfactory product which was readily consumed and produced greater gains in steers than in those fed a corn-and-cane silage. A high-grade silage readily consumed by beef cattle was also prepared from green soybeans in which culled sweetpotatoes were added at the rate of about 3.5 bushels per ton of soybeans.

Silage prepared from a mixture of alfalfa and bromegrass plus 80 pounds of molasses per ton proved very similar to corn silage for milk production in two feeding experiments conducted at the Indiana station. The higher carotene content of the alfalfa-bromegrass silage was reflected in higher carotene values of the blood plasma and butterfat and in higher total vitamin A values of the milk fat.

Bluegrass-molasses silage made from mature grass of poor quality was compared with silage from immature grass of good quality, in experiments at the Kentucky station. The silages contained 6.0 and 15.3 pounds digestible protein and 58.5 and 75.2 percent total digestible nutrients, respectively. When fed in combination with alfalfa hay and shelled corn in steer-fattening tests, the gains were in keeping with the results of the digestion experiments. The importance of ensiling grass before reaching full maturity is thus emphasized.

Feeding tests by the Mississippi station showed that Johnson grass cut with a silage cutter and ensiled with or without preservatives is

about equal to sorghum silage. The carotene content of the Johnson grass silage was about three times that of the sorghum silage. Efforts to ensile unchopped Johnson grass were unsuccessful since it was impossible to pack the long material in the silo satisfactorily.

Silage prepared from a mixture of 25 tons of corn and 1 ton of carrots by the Ohio station was in good physical condition 2 months after silo filling. Carrots similarly ensiled with alfalfa were slightly softer than those ensiled with corn. In two tests the silage containing the carrots either with corn or alfalfa was highly palatable to cows, and good yields of milk and butterfat high in carotene were secured.

Peppergrass (*Lepidium virginicum*) ensiled with molasses at the Virginia station produced a palatable silage that had no peppergrass flavor. No undesirable flavor was imparted to the milk or butter produced by four cows receiving the silage. After fermentation in the silo, the seeds did not germinate which eliminated the possibility of spreading peppergrass from manure of cattle fed the silage.

Control of acidity in silage.—From detailed biochemical and bacteriological studies of 38 silages made with different treatments the Pennsylvania station concluded that the most important single factor to insure preservation of grass silages is an adequate supply of fermentable sugars either present in the original plant material or added to it. Usually satisfactory silage was produced if the pH was below 4.2 percent. Above this pH, without reserve sugar, the lactic acid bacteria converted the lactic acid to acetic acid, lowering the acidity and decreasing the quality of the silage.

A pronounced acidity in the urine and blood, with an accompanying sharp increase in ammonia excretion, was observed in dairy cows fed oats silage made with additions of 20 pounds of 68 percent phosphoric acid per ton in trials at the New Jersey station. Sodium bicarbonate in the diet was about twice as efficient as limestone in counteracting the acidity. Sodium bicarbonate and limestone fed in sufficient amounts to neutralize two hydrogens of the phosphoric acid in the silage was adequate, and the combination was probably the most satisfactory for practical purposes. A grain mixture with 2 percent limestone mixed with alfalfa and timothy hay proved ineffective in preventing acidosis when the phosphoric acid-oat silage was fed over a 100-day period.

Utilization of silage.—In a test at the Iowa station with yearling steers, only 0.44 acre was needed to grow the silage, corn, and hay for a silage-fed steer as compared with 0.84 acre required to grow the corn and hay for a steer full-fed corn and alfalfa. The steers fed 175 days on corn silage, 1 pound of alfalfa hay, 1½ pounds of soybean meal, simple minerals, and salt, with corn added only for the last 40 days, gained 344 pounds per head and produced 781 pounds of beef per acre of land required to grow the silage, corn, and hay. Cattle full-fed corn with alfalfa hay for roughage, although gaining 411 pounds per head, produced only 489 pounds of beef per acre.

Feeding tests at the New Mexico station showed that corn silage, with alfalfa hay, ground kafir, and cottonseed meal, fed to yearling steers produced greater gains and more profit than either ground hegari fodder or cottonseed hulls fed in similar rations. Corn silage and alfalfa hay formed a more efficient roughage for fattening yearling steers than corn silage alone.

In a series of comparative trials at the Kansas station both oatgrass silage and artificially dehydrated alfalfa meal were markedly supe-

rior to sun-dried alfalfa as sources of vitamins A and G for growing chicks and laying hens. Over a 1-year period a much higher percentage of the carotene was retained in the silage than in the alfalfa meal. The silage could not be depended upon as a primary source of vitamin G for young chicks because of limited consumption. Limiting silage to 2 to 3 pounds daily per 100 layers improved the ration without causing "grass eggs."

Similarly in trials with oat silage, the West Virginia station concluded that the feeding of 2½ pounds of silage daily per 100 layers effectively improved the hatchability of eggs without adversely affecting yolk color. The station also found that young chicks cannot consume a sufficient quantity of oat silage to provide a protective level of vitamin G, or riboflavin, in the diet.

BETTER USE OF HAY

Hay constitutes the backbone of the winter feeding program for cattle, horses, and sheep, approximately 100,000,000 tons being consumed annually in the United States. Research on ways of improving the quality and increasing the usefulness of hay in the ration of farm animals, therefore, is of foremost importance.

Nutritive value of hays.—A detailed study of lespedeza hays harvested at the prebloom, medium-bloom, and seed stages by the Kentucky station gave evidence that the early cut hay contained approximately 30 percent more total digestible nutrients than the late cut hay. The medium cut hay was intermediate with respect to these nutrients.

The Vermont station has completed an extensive series of studies comparing the conservation of nutrients in common legumes and grasses as silages and as hays. Dry-matter losses during curing and storage were as follows: As silage in small silos—23 percent without preservative, 20 percent with molasses, and 17 percent with phosphoric acid, or an average of 20 percent; as sun-cured hays from standing grass to fully cured hay out of the mow—24 percent for first-cutting alfalfa and 13 percent for second-cutting; 36 percent for red clover and 9 percent for timothy, or an average of 20 percent. Dry-matter losses in the artificially dried hays averaged 5 percent. On a dry-matter basis, hays and silages from the same crop were similar in nutrient composition. After 8 months' storage, sun-cured hays had lost about 85 percent, artificially dried hays 47 percent, and silages 38 percent of their initial carotene content.

Under South Dakota conditions vitamin D in alfalfa hay develops as rapidly in small windrows as in the swath, according to the South Dakota station. In large windrows less vitamin D develops than in the swath and small windrows and still less develops in cocks. Losses of carotene are less from the windrow than from the swath and still less from cocks. The use of proper harvesting methods to obtain alfalfa hay high in vitamin D and carotene content is an effective way to promote good growth, efficient production, and vigorous health in livestock fed this hay.

According to the Georgia and Oklahoma stations good-quality peanut hay compared favorably with other common hay crops in feeding value. The Georgia station found peanut hay practically equal to pea vine hay and slightly superior to lespedeza for wintering

dairy heifers, while the Oklahoma station found peanut hay approximately equal to good alfalfa hay for milking cows. These findings are highly significant in view of the marked expansion in peanut production throughout the South in recent years.

Preventing bloat from alfalfa.—Fine-quality first-cutting alfalfa hay when fed to fattening cattle as the only roughage at the New Mexico station frequently caused severe bloat. This trouble occurred much less frequently, however, when coarser third-cutting alfalfa was fed. The danger of bloat was reduced materially by adding a limited amount of cottonseed hulls to the alfalfa ration.

Sorghum fodder.—Fodder from a variety of sorghum having low prussic acid content proved valuable and highly palatable for wintering breeding ewes, in trials at the South Dakota station. All of the sorghum heads, leaves, and smaller parts of the stalks were consumed. The ewes were healthy and free from disease, and the indications were that good lamb crops would be produced in each lot. The results to date indicate that such sorghum fodder can be included in rations for pregnant ewes. The use of sorghum fodders properly supplemented should help solve the shortage of farm feeds and cheapen wintering costs in many areas of South Dakota.

Sugar beet tops and alfalfa.—Sugar beet tops and alfalfa hay fed as the roughage to cows on a well-balanced grain mixture resulted in the production of more milk than the same grain mixture with alfalfa hay alone, in a series of experiments at the Nebraska station. Apparently beet tops did not cause the cows to dry off or cause digestive disturbances. These experiments dispelled a common prejudice against the use of beet tops for milking cows.

Dried vegetable wastes.—Waste from dried pea vines, lima bean vines, turnip tops, broccoli, and carrot tops may be fed in amounts as high as 8 percent of the total feed in broiler mashes, according to findings of the Delaware station in cooperation with the Department. Vegetable wastes substituted for equal amounts of alfalfa leaf meal gave comparable gains without harmful effects. These findings indicated the possibility of converting such vegetable wastes, which heretofore have been little used, into valuable feed products. Similarly, dehydrated pea vines were found by the Maryland station to be superior to a good quality of dehydrated alfalfa meal in a starting and growing ration containing soybean meal as the sole protein supplement.

In a study made by the Georgia station to determine the feasibility of dehydrating legume and other leaf meals, kudzu was found to be very promising. The dehydrated product was rich in carotene, riboflavin, protein, and calcium.

FEEDING GRAINS AND GRAIN SUBSTITUTES

No problem confronting livestock producers during the past year has been more acute than that of extending a limited supply of feed grains, about 2 percent below that of the preceding year, to support a livestock population approximately 7 percent larger than a year earlier. Recent findings of the experiment stations have aided in meeting this acute situation.

Producing beef with less corn.—Illinois station experiments showed that cattle grown on pasture and roughage without concentrates until approximately 2 years old and then given the finish

required on Good carcasses produced a pound of edible meat (boneless lean plus 25 percent of fat) by the use of less corn than is required to produce a pound of boneless pork. The feeding of 2-year-old steers to Choice finish was found wasteful of grain since two Choice feeders were brought to Good finish on the amount of corn (about 4 bushels required) required to bring one Choice feeder to Choice finish. To bring Good cattle to Choice finish required 86 bushels of grain per head as compared with 30 to 35 bushels for similar cattle stopped at Good finish.

Giving special consideration to the necessity of feeding grain to stock calves during their first winter, the Kansas station fed one lot of good-quality steer calves sorgo silage and cottonseed cake only. Two similar lots received, in addition to the silage and cottonseed cake, 4.2 and 8.3 bushels of grain per head, respectively. The average winter gains in the three lots were 159, 183, and 209 pounds per head, respectively. All three lots were raised together during the summer. At the end of the grazing season there were only 3 pounds per head difference in the three lots. This emphasizes that good growth and development can be secured on stock calves without feeding grain the first winter.

Dried beet pulp effectively replaced up to one-half the corn in steer-fattening trials at the Nebraska station. There were only slight differences in rate of gain and in the amounts of feed required per unit of gain. In market and slaughter quality, steers fed mixtures containing dried beet pulp were fully equal to steers finished on shelled corn alone.

Wheat as a substitute feed for corn for cattle feeding.—Until the recent acute corn shortage the use of wheat as a feed for livestock, except for poultry, had been an unusual practice. The Oregon station found that as much as 75 percent of the grain ration for milk cows can be in the form of ground wheat, but that 50 percent is the optimum extent of its use without some loss in palatability. This knowledge made possible use of wheat in emergency rations in areas where other feed grains were deficient and was helpful in meeting numerous war food-production problems involving feed-grain deficiencies.

Results from a study at the Oklahoma station showed that ground wheat can be safely fed as a complete substitute for corn by mixing it with silage or cottonseed hulls. Ground wheat proved to have 107 percent of the value of ground shelled No. 2 corn when mixed with silage and 102 percent of the value of ground shelled No. 2 corn when mixed with cottonseed hulls. Shelled corn is, however, more palatable than ground wheat. This research established a practical way to substitute ground wheat for all of the corn in a cattle-fattening ration.

Distillery slop in cattle feeding.—When feeders complained that the new wheat-distillery slops coming from wartime production for industrial alcohol were inferior in feeding value to corn slops and in some cases toxic or even lethal to cattle, the Kentucky station promptly undertook a study of this important problem. The whole-wheat slops were found fully equal in feeding value to slop made from half-corn mashes, producing better than 2 pounds of gain on good steers when fed with 5 pounds of hay, salt, and limestone. In general, the complaints were traced to improper feeding, involving presence of molds in hay or deficiencies in vitamin A. In some cases, however, slops were

found to contain large amounts of alcohol because of faulty distilling apparatus.

Grain sorghums as substitutes for corn.—Sorghum grain is assuming an increasingly important role throughout the Great Plains region, where yields of sorghum commonly excel any of the cereals. A comparison at the Nebraska station of three varieties of ground sorghum grain versus cracked corn in the ration of fattening steers gave evidence that the sorghum grains were as easy to feed as corn and gave approximately the same average daily gains. The efficiency of gain favored corn, however, since only 90 to 96.5 percent as much corn as sorghum grain was required per unit of gain.

Producing pork on Great Plains area feeds has received special consideration. Results at the Kansas station indicate that pork can be produced satisfactorily with grain sorghums. Hogs fattened in a dry lot gained 1.46 pounds per head daily on shelled corn, 1.52 pounds on ground Colby milo, and 1.49 pounds on ground Wheatland milo.

Similarly, there was no significant difference in the average daily gains of pigs fed Martin milo, Plainsman milo, hegari, or wheat in trials at the Texas station. However, more sorghum grain than wheat was required per unit of gain. Whole or unground wheat in these tests was worth 17 percent more than unground Martin or Plainsman milo and 6.85 percent more than unground hegari. Ground wheat in these tests did not produce any faster gains than did whole wheat, but, owing to the saving of feed required per 100 pounds of gain, the ground wheat was worth 14.8 percent more than was the whole or unground wheat. Likewise, ground Martin milo was worth 3.2 percent more than was whole Martin milo.

In two feeding experiments by the Texas station the replacement of ground yellow corn by ground milo, either with or without supplementary carotene, did not significantly change the value of the ration for growing chicks. Actually, slightly more rapid and more efficient gains to 12 weeks of age were made by chicks on the unsupplemented milo ration in each trial. Thus, when adequate carotene is supplied by good quality alfalfa leaf meal, as in these experiments, milo satisfactorily replaces an equal weight of corn in rations for broilers.

In a series of trials with White Leghorn and Rhode Island Red pullets at the North Dakota station the results indicate that the substitution of proso millet for yellow corn in both the scratch and mash rations did not significantly affect egg production, egg size, mortality, or pullet weight in either breed, although hatchability of the fertile eggs in both breeds was definitely improved. The total feed consumption was slightly greater by both breeds when millet replaced corn.

Unusual feeds for dairy cows.—Wild mustard (*Brassica arvensis*) seed and pennycress (*Thlaspi arvense*) seed constitute a high percentage of the dockage in grains in the Great Plains area. Both were found by the Montana station to be relatively rich in protein and fat. When the finely ground seeds were used to replace soybean meal in a conventional-type dairy ration, the feed required to produce a unit of milk or butterfat was practically the same on the soybean meal or pennycress seed rations and slightly lower on the wild mustard-seed ration. When the rations containing the weed seed were fed immediately after milking, no undesirable flavor was imparted to the milk.

There was no indication that the feeding of either weed seed was detrimental to the health of the cow.

Three years' experiments at the Maryland station showed ground cheat (*Bromus secalinus*), when fed as 30 percent of the grain ration, to be the equal of barley for milking cows. Field experiments showed that cheat usually outyields oats and, under many conditions, barley also. Thus, a plant usually considered as a weed has definite possibilities as a feed grain.

Fat in animal rations.—Comparing ground soybeans and soybean meal as supplements for alfalfa hay in the ration of milking cows, the Oregon station found that the high-fat ration favored milk production, the average increase being 7 percent. The feeding of ground soybeans or soybean meal with alfalfa hay allowed milk and butterfat production to be maintained above or at least equal to what is expected of cows on good rations throughout the lactation.

On the other hand, the Ohio station found no significant differences in the production of milk or butterfat or in the general health of milking cows from the feeding of practical grain mixtures ranging in average fat percentage from 2.69 to 4.89. These findings are significant in that it apparently makes little difference whether grain mixtures are balanced for protein content by the addition of solvent-extracted meals, expeller meals, or ground oil seeds.

Effective rations for fattening lambs.—Wet beet pulp was more efficient than alfalfa silage or corn silage when fed with a grain mixture and good alfalfa hays, in trials at the Colorado station. Alfalfa silage was calculated as having 88 percent of the value of corn silage. The least efficient ration in the test was the grain mixture fed with ground alfalfa and no succulent roughage. The carcasses of animals fed this ration ranked low in dressing percentage.

Cane molasses.—This may be fed safely and effectively to young growing pigs at higher levels than is commonly considered practical, according to findings of the Hawaii station. About the same daily rate of gain was secured from rations containing 0, 10, or 20 percent molasses. This fact should aid considerably in decreasing the cost of growing pigs in the Territory, for molasses is inexpensive and abundant.

Laying hen mortality.—The mortality among laying hens is significantly affected by the kind of grain used in the ration, as shown in experiments over a number of years at the California station. A ration of which the mash consisted of about one-half yellow corn and the scratch of one-third corn, one-third wheat, and one-third barley, each fed continuously during the first 18 months of life, produced a significantly higher laying-hen mortality than a similar ration in which the corn of the mash was largely replaced by barley. Differences in mortality were largely accounted for by an increase in the pathological condition of the reproductive tract.

Garbage from military kitchens.—This has been fed experimentally at the Hawaii station. Raw garbage proved to be significantly higher in nutritive value than cooked garbage when fed to fattening pigs as a supplement to a basal ration of barley, cane molasses, meat meal, soybean meal, and minerals. About 50 pounds of the mixed feed and 809 pounds of raw garbage were required per 100 pounds of gain, as compared with 66 pounds of mixed feed and 875 pounds of cooked garbage. Cooking garbage for pigs, therefore, was uneconomical

since it not only reduced the feeding value but involved considerable cost in labor, fuel, and equipment. Raw garbage, when fed with a high-vitamin mash of alfalfa and mill run with steamed bonemeal and fish oil, reduced the cost of producing a pound of Muscovy duck meat from 18½ to 7 cents. Tests showed, however, that ducks will not grow on raw garbage and green feed alone.

Further tests by the Hawaii station with fat-extracted dehydrated garbage meal (noted in the 1943 annual report) indicated that this material can be used advantageously in normal rations for fattening poultry. The value of the meal was within the range of $80 to $120 per ton. Experiments are now in progress to evaluate the meal for egg production in both normal and emergency rations and for fattening poultry in emergency rations.

CONSERVING PROTEIN FEEDS

The extending of limited supplies of high-protein concentrates to meet the essential requirements of a larger livestock population has been a knotty problem throughout the war period requiring strictest economy in the use of protein supplies. The following examples illustrate the manner in which research has aided in meeting this problem.

Protein from soybeans.—Attention has been given to the most effective way of utilizing soybean protein for all types of animals in view of the enormous expansion in soybean production during the past 2 or 3 years.

Cracked soybeans (11.1 percent of the grain concentrates), when fed as a substitute for linseed meal in the ration of dairy cows at the Iowa station, did not result in objectionable flavors in milk, nor was such milk more subject to oxidation than milk produced when the cows were fed linseed meal. Since cracked soybeans, in spite of their high oil content, may be fed without affecting milk flavor, dairy farmers can grow their own protein supplements for feeding dairy cows.

Soybean meal prepared from frosted or field-damaged soybeans was practically equal to meal from normal beans, according to findings of the Colorado and Illinois stations. At the Colorado station there were no significant differences between lots of chicks on meal from frost-damaged and normal soybeans when fed with meat and bone scraps, but the meal from the damaged beans was slightly inferior to meal from normal beans when no meat and bone scraps were included. At the Illinois station soybean meal from beans showing 10- and 40-percent field damage proved as nutritious and as palatable for chicks from hatching to 6 weeks of age as meal from unspoiled beans. These findings are highly significant in view of the difficulties encountered in attempting to harvest soybeans in prime condition.

Plant protein for swine.—A question of current interest and importance is how far protein from plants may be substituted for an animal-protein concentrate as a supplement to grain for swine.

Soybean meal, tankage, and combinations of protein concentrates were compared as supplements to corn and minerals for pigs on pasture in a series of experiments by the Ohio station. The pigs fed soybean meal gained as rapidly but required a trifle more feed for each pound of gain produced than those fed tankage. There was little difference in the cost of the gains. The value obtained from the soybean meal was slightly more per pound of protein than that of

the tankage. With pasture, a plant-protein feed successfully replaced all of the animal protein feed, a single protein concentrate being practically as effective as mixtures of plant or of plant- and animal-protein concentrates.

Of a number of supplements to corn fed to hogs by the Louisiana station, soybean meal and peanut meal with or without tankage gave approximately the same results as to economy of gain and were superior to tankage alone. The peanut meal gave larger gains.

A more difficult problem is involved in providing adequate rations for young growing pigs. At the Illinois station a ration of corn, wheat middlings, and soybean meal, fortified with cod-liver oil and minerals, when fed to pigs in dry lot continuously from farrowing, proved grossly inadequate in supporting growth even when supplemented with six members of the vitamin B complex or 10 percent of alfalfa meal. A basal diet containing tankage and fish meal in addition to corn, wheat middlings, and soybean meal also was inadequate but superior to the vegetable-protein basal. The addition of synthetic B vitamins to the animal-protein basal mix induced rapid growth. The plant-protein basal rations gave satisfactory results when fed in dry lot to pigs that had had access to rye pasture before weaning, indicating that pigs on pasture build up a reserve of certain nutritive factors which enables them to withstand a deficient diet fed at an older age.

Combinations of proteins for poultry.—Rapid strides have been made in learning how to supplement vegetable proteins so that relatively large amounts of them can be utilized in rations for chickens and turkeys.

Studying the results of using a higher percentage of soybean meal as a source of protein in the poultry laying ration, the Washington and western Washington stations obtained as satisfactory egg production by feeding a protein concentrate containing 25 percent herring fish meal and 75 percent soybean meal as by feeding higher levels of animal protein.

Trials were also carried out by the Washington station on desirable protein mixtures for growing chicks. Excellent results in net gains and feed utilization were obtained with protein supplements of herring fish meal, 30 percent; soybean meal, 35; and Alaska pea meal, 35; or herring fish meal, 25; soybean meal, 25; cottonseed meal, 25; and Alaska pea meal, 25 percent.

In New York (Cornell) station experiments maximum development of chicks could not be obtained on soybean products alone. About 2 percent of fish meal, meat scrap, or dried skim milk were needed to obtain full growth. Tests of choline as a supplement to soybean meal did not overcome the difficulty. Hatchability of eggs was decreased by a full soybean ration.

Over a 7-month period a flock of pullets at the New Hampshire station fed a ration containing meat scrap as a source of animal protein produced a few more eggs per bird than a similar flock fed a ration containing vegetable protein only with soybean meal in place of meat scrap. The latter group, however, lived and maintained their weight as well as the former. Thus, flocks can be maintained in reasonably satisfactory production if necessary in an emergency without animal proteins.

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Egg production was reduced in a 20-week trial at the Delaware station, where 10 percent meat scrap, 5 percent dried milk, and 5 percent alfalfa meal were replaced with 10 percent soybean meal, 5 percent distillers' grains with solubles, 7 percent alfalfa leaf meal, and 2.5 percent meat scrap.

Less protein was used by both Rhode Island Red and White Leghorn pullets in balancing their ration when the mash contained either 20, 26, or 33 percent protein and was self-fed along with whole corn and whole oats, as compared with a 17-percent all-mash ration in experiments at the Wyoming station. On the free-choice method of feeding, the birds laid as many eggs as those getting a ration containing 17 percent protein, but they consumed less protein.

Feeding a low-meat mash containing less than 10 percent animal protein to poults to 8 weeks of age in trials at the Nevada station significantly lessened the rate of gain as compared with that of another group on a ration of 12 percent animal protein. The two groups averaged 2.26 and 3.01 pounds, respectively, at 8 weeks of age. Differences in early growth did not persist through the later growing period. Evidently soybean meal may be substituted for fish or meat meal so that the percentage of animal protein constitutes only 12 percent of the total protein, without reduction in rate of growth.

Sources of protein for young calves.—In order to reduce the amount of milk used in calf rearing, a number of studies have been directed to the development of suitable rations for young dairy calves. Experimenting with different combinations of skim milk, dried whey, and blood meal in the rations of young dairy calves, the Nebraska station found that a mixture of 3.2 parts of dried whey and 1 part of dried blood is a satisfactory substitute for skim milk, 6.8 pounds of the mixture replacing 50 pounds of the skim milk. The station concluded that healthy dairy calves can be raised satisfactorily from 3 weeks to 6 months of age on as little as 50 pounds of skim milk if it is properly supplemented with dried whey, blood meal, alfalfa hay, a grain mixture, and a vitamin concentrate. This offers a way of diverting milk from calf feeding to human food and to other uses.

A new dry starter containing dried whey and alfalfa meal, developed by the Maryland station, gave daily gains of 1.2 pounds for the first 26 weeks, as compared with 1.3 pounds with a pre-war mixture containing skim milk and cod-liver oil.

In a detailed investigation of the physiological effects of an all-vegetable protein dry ration for calves, the New Hampshire station found that for Holstein and Guernsey calves dry rations with soybean meal as a major source of protein and dried distillers' solubles as a source of the B vitamins produced normal growth equal to that on dry rations containing 25 percent skim-milk powder.

Colostrum produced in excess of calf needs on large dairy farms can be frozen and preserved all winter at little cost in the northern part of the United States and used for calf feeding in place of marketable milk, which can be sold for human consumption. That calves will thrive on a diet with colostrum entirely replacing milk even up to 63 days after birth was indicated by tests at the Vermont station. All the calves grew satisfactorily.

Nutritive deficiencies in proteins.—Many proteins are lacking in one or more of the amino acids essential for animals and hence are

inadequate as a sole source of protein, although they may have marked value in a mixture of two or more protein feeds.

Studies were conducted by the Indiana station to determine the nutritive value of distillers' dried solubles as a protein supplement. The proteins of this product, derived from the proteins of yeast and cereal grains, were found incapable of supplementing corn. In determining the amino acid deficiencies of this product by feeding tests with albino rats, the station found that at a 20-percent protein level in the ration a critical deficiency of lysine exists, while at a 15-percent protein level tryptophan is also deficient. At a 10-percent protein level additional amino acid deficiencies occur. When distillers' dried solubles are used as a supplement to corn the amino acid deficiencies can be corrected by additions of lysine and tryptophan. These deficiencies can also be corrected by additions of small amounts of casein or yeast.

Earlier work by the California station having shown that low methionine content is a limiting factor in the use of soybean meal as a sole source of protein in chick rations, the station made analyses of a number of feedstuff proteins as naturally found and consumed. As compared with other plant proteins, sesame meal was found to have a relatively high content of methionine. Sesame meal alone did not support growth of chicks, but good growth was obtained with a combination of sesame and soybean meals.

Alaska field peas were found by the Idaho station to be relatively complete for the chick in known essential amino acids except methionine. Chicks receiving Alaska peas as the primary source of protein grew slowly, whereas the addition of one-half percent of methionine to the diet resulted in approximately four times more rapid growth. With adequate amounts of methionine, the proteins of peas were more efficiently utilized than were the proteins of a control ration consisting of herring fish meal, meat meal, and dried milk.

New possibilities for using blood-cell proteins, now largely a waste material, in chick feeding have been opened up by the findings of the California station that the primary defect in blood-cell proteins for the growth of chicks is a deficiency of amino acid isoleucine. Blood-cell protein may be utilized in chick feeding when supplemented by other natural sources of protein which are rich in isoleucine.

Using newer methods of determining amino acids in protein, studies at the Georgia station have shown that the tryptophan content of peanut proteins is lower than the values generally accepted heretofore. The low value for this essential amino acid at least partially accounts for the weakness of this protein in nutrition, particularly that of poultry.

New or unusual sources of protein.—Of particular interest as a further means of alleviating the shortage in feed proteins are new and unusual sources of protein.

Ground mung beans proved a satisfactory substitute for cottonseed meal in a standard hog-fattening supplement mixture of 2 parts meat scrap, 1 part cottonseed meal, and 1 part dehydrated alfalfa hay in trials at the Oklahoma station. Also, ground mung beans gave excellent results as protein suplpements for growing and laying mashes for chickens, but minerals and a small amount of animal protein were needed for best results. Forty percent mung bean meal supplemented with 5 percent meat and bone scraps and 2 percent bonemeal adequately

replaced the usual animal protein supplements. However, mung beans were not palatable to lambs when fed at a rate of more than 0.3 pound per head daily. Levels of 0.4 pound or better would throw the lambs off feed.

Experimenting with unproved material as possible sources of poultry feed, the Maryland station found that starfish meal at 3-percent levels effectively supplemented a chick mash in which soybean meal was the only high protein feed, proving practically as effective as 4 percent commercial fish meal. The shank color as well as growth to 9 weeks of age was improved by additions of the starfish meal to the basal ration. This station also found sprouted soybeans to be little, if any, better than unsprouted soybeans when fed to chicks as the sole protein supplement.

Experimenting on the feeding value of a product made by drying crab waste, the Massachusetts station obtained rapid growth and good feathering, desirable pigmentation, and feed efficiency in chicks on rations containing the dried crab meal in place of all of the meat and skim milk in the New England College Conference rations. The flavor of the cooked meat of birds receiving the crab meat was not objectionable. For best results the ration should contain several other protein sources, and the calcium content and the ratio of calcium to phosphorus should be adjusted to conventional levels.

Unhatched incubation eggs may be utilized to good advantage in poultry rations, according to a report of the Ohio station. In one experiment 5.5 cents was realized per pound of cooked incubator eggs used in supplementing a complex ration for pullets and cockerels. The feeding of 155 pounds of cooked unhatched incubator eggs produced 14 pounds more weight increases and made possible a saving of 131.5 pounds of mash. The infertile unhatched eggs were boiled 30 to 45 minutes before being fed, to avoid disease transmission, and were passed through a meat chopper. The eggs should not be kept more than 1 to 2 weeks after cooking.

Urea as a protein substitute.—From 3 years' experimentation the Massachusetts station reports that urea, when used to supply 42 percent of the total nitrogen in the grain ration or 25 percent of the total nitrogen in the entire ration, is only slightly inferior to normal protein concentrates for body maintenance and milk production of dairy cows. This finding and earlier reports by the Wisconsin and Hawaii stations indicate the feasibility of using urea in dairy rations to aid in alleviating an acute shortage of protein concentrates during the present emergency period.

Calves as young as 2 months of age were able to utilize urea as a source of nitrogen for growth in trials at the New York (Cornell) station. Calves receiving the basal ration only, containing 4.4 percent protein, were unable to make much growth and were in negative nitrogen balance. Those receiving rations containing urea to give a calculated protein content of 16.2 percent made fair gains up to about 6 months and were in positive nitrogen balance.

Studies at the Wisconsin station on the influence of various ingredients in the ration on the utilizatiton of urea by growing dairy heifers gave evdence that with hay as the sole ingredient of the basal ration utilization of urea was low, whereas the addition of molasses provided a suitable substrate for the development of an active paunch flora so that urea was fairly well utilized. Adding also a fermentable, un-

soluble carbohydrate, such as cornstarch, further improved urea utilization.

Urea treated silage.—The possibility of improving the nitrogen content of rations through the addition of urea to various types of nonlegume silages has been investigated.

A preliminary report by the Mississippi station last year that sweet sorghum silage treated with 10 pounds of urea at the time of ensiling was superior to untreated silage for wintering mature beef cows has been confirmed in later trials by the station.

Sweet sorghum silage was prepared at the Florida station with additions of urea ranging from 10 to 50 pounds per ton. Urea determinations on silage as it entered the silos and after removal indicated that comparatively little of the urea was changed. Free ammonia was noticed in the silage containing the highest level of urea but in none of the other silages. Determination of pH in the silages gave values between 3.5 for the control and 7.6 for the 50-pound level of urea. The cattle ate the silages containing no urea and 10 pounds of urea per ton about equally well, followed by that containing 30 pounds per ton. The 50-pound-per-ton silage was refused entirely until much of the free ammonia had disappeared from it.

Normal corn silage and corn silage treated with 10 pounds of urea per ton were compared at the South Carolina station. The only notable difference in the dry-matter content of the fermented silages was in crude protein, which was 10.79 percent for the treated and 7.48 percent for the untreated. Average carotene values per gram of dry matter were 11.50 micrograms for the urea-treated silage and 36.58 micrograms for the untreated. The corresponding pH values were 4.3 and 3.6. The palatability of the treated silage was somewhat lower. The productive values of the two silages when fed to milking cows as the only roughage along with a normal concentrate ration were similar, indicating that treating corn silage with urea did not improve the feeding value of the resulting silage.

PROVIDING NEEDED VITAMINS AND MINERALS

The fact is well established that deficiencies in essential vitamins and minerals retard the productive performance of animals and reduce the efficiency of feed utilization even though the major nutrients are adequately supplied. Recognizing the many minor nutritive factors required by animals and providing adequate amounts of them in rations are important steps in attaining maximum efficiency from feeds and safeguarding the health of animals.

MEETING VITAMIN REQUIREMENTS

New facts regarding conditions under which vitamin deficiencies occur among different types of animals and ways of alleviating such deficiencies have been provided through station research.

Sources of vitamin A for cattle.—At the Indiana station in feeding experiments with milking cows in which a low vitamin A basal ration was supplemented with graded levels of fish-liver oil, maximum vitamin A value in the butter was secured at a daily intake of 200,000 units of vitamin A, whereas about 550,000 units of carotene in alfalfa hay were required to give comparable values. Thus, vitamin A per se (fish-liver oil) is approximately three times as effective as carotene

for this purpose. From similar experiments in which the low vitamin A basal ration was supplemented with varying levels of dehydrated alfalfa hay or crystalline carotene suspended in oil, the station concluded that dairy cows can utilize carotene from alfalfa hay as readily as isolated carotene.

Dehydrated alfalfa leaf meal, grain sorghum silage, and sweet sorghum silage were compared as sources of carotene in rations for fattening yearling Hereford steers in a trial at the Texas station. The results indicated that carotene in dehydrated alfalfa leaf meal was more available than that in grain sorghum silage, a level of 1,800 to 2,000 micrograms in the former having greater effect in controlling vitamin A deficiency than levels of 2,200 to 2,600 micrograms supplied by the latter.

Vitamin requirements of young calves.—Noteworthy advances have been made in determining the vitamin needs of calves. The addition of a carotene concentrate and vitamin D as irradiated yeast to a standard calf-starter ration in experiments at the Pennsylvania station markedly increased the thriftiness and growth rate of calves as compared with those of calves on an unsupplemented ration, especially during the winter months when the animals have a higher vitamin requirement than in warmer seasons. Use of the calf starter thus fortified with vitamins permitted the elimination of milk from the calf feeding ration at an early age.

Young calves were found by the Wisconsin station to have specific requirements for vitamins A, C, D, and nicotinic acid, despite the general assumption that the cow is self-sufficient in the synthesis of vitamin C and the vitamin C complex. Vitamin C synthesis apparently did not begin until the calves were 2 to 3 weeks of age. In the meantime adequate amounts of the vitamin were essential in protecting the calf from navel ill, peritonitis, and other active infections. It appeared also that the young calf cannot convert carotene into vitamin A. Administration of vitamin A and nicotinic acid was effective in controlling all types of calf scours except that associated with septicemia in the newborn. Calves were raised successfully from birth on a diet of skim milk with added amounts of vitamins A, C, D, and nicotinic acid and access to hay and grain.

A dermatosis, or skin disease, of young calves under certain barn feeding conditions has been observed by the Michigan station. Study revealed that the disease is accompanied by exceedingly low blood-plasma ascorbic acid values and responds to ascorbic acid therapy.

Vitamins for pigs.—The importance of adequate sources of the B-complex vitamins in swine rations was clearly shown in experiments at the Wisconsin station. Pigs receiving a simple ration of yellow corn, soybean meal, 5 percent alfalfa meal, and minerals responded favorably to additional carriers of B-complex vitamins, including dried distillers' solubles, dried brewers' yeast, or more alfalfa meal. They also obtained helpful supplements from freshly collected cattle manure. This response was not due to any whole undigested corn contained in the manure, but suggests the presence of certain vitamins.

No single supplement to a basal ration devoid of green feed was as satisfactory as dehydrated young cereal grass in promoting appetite, growth, and smooth hair coat on growing pigs in trials at the Arkansas station. Young cereal grass supplies some factors needed for swine which are lacking in corn and milk. Chief among the benefits

derived from the green-feed factor are improved reproduction, lactation, and better hair coats.

Vitamin A for poultry.—A detailed study by the Connecticut (Storrs) station of chickens affected by vitamin A deficiency led to the conclusion that subtotal vitamin A deficiency may be recognized by means of histopathologic examination of the nasal passages. Nasal pathology reflects more directly the physiologic minimum requirement for vitamin A than average-growth records and liver storage. This test may therefore be useful in establishing vitamin A requirements.

Feeding trials at the Maine station, in which second-cutting Ladino clover was fed in the ration in the form of dehydrated meal, sun-cured hay and meal, and silage in comparison with alfalfa leaf meal in laying rations, showed that these Ladino products can be substituted satisfactorily for alfalfa leaf meal. The dehydrated Ladino meal and silage were much higher in carotene than Ladino hay and hay meal and alfalfa meal. The work points to the possibility of developing a valuable feeding product for poultry from Ladino clover.

In a study to ascertain the relationship between vitamin A deficiency in hens and ascorbic acid storage the Maryland station found that the ascorbic acid content of the livers and duodena of vitamin A-deficient hens was as great as that of the same hens fed ample vitamin A, indicating that vitamin A deficiency does not interfere with ascorbic acid synthesis in the mature chicken as it does in cattle and rats.

The chick cannot quickly utilize vitamin A and carotene unless vitamin E is present in adequate amounts, according to findings of the South Carolina station. Vitamin E appeared to be antioxidant and it helped to prevent oxidation of vitamin A and carotene in the diet and also in the gastrointestinal tract.

Vitamin D for poultry.—Vitamin D concentrates vary in their effectiveness for growing turkeys, according to the Pennsylvania station, which found that 80 A. O. A. C. units of vitamin D from irradiated animal sterols per 100 grams of feed were adequate for poults, whereas 200 units were needed when the factor was supplied in vitamin fish-oil products, including Reference cod-liver oil.

Similarly, the California station found that on a vitamin D-unit basis irradiated animal sterol and also certain fish-oil blends were markedly superior to Reference cod-liver oil for turkey poults.

Vitamin D-fortified fish-liver oils vary in their ability to retain high potency during storage, according to the Washington station. After 8 months' storage at 50° to 90° F. there was a loss in vitamin D potency of 26 percent in herring oil and 19 percent in dogfish-liver oil, but no loss in the potency of pilchard, pink salmon, or sockeye-salmon waste oils. There was no appreciable loss in vitamin A potency during storage.

Premixing vitamin D carriers, including D-activated sterols from animal sources and fish oils, with salt and calcium carbonate and storing at room temperature for 3 weeks before incorporation into the ration destroyed a large part of the vitamin D in trials at the Oklahoma station. The weights and ash content of tibias of poults at 3 weeks of age were as good with 100 units added fresh per 100 grams of feed as with 1,000 units after premixing and storing.

The B vitamins for poultry.—The substitution of large amounts of vegetable protein for animal proteins, particularly milk products, has

created an acute problem of supplying adequate amounts of riboflavin and other members of the vitamin B complex in poultry rations.

Corn distillers' grains with solubles satisfactorily replaced dried skim milk and wheat bran, wheat middlings, or ground oats in chick starting rations, with improvement in feed efficiency, in trials at the Massachusetts station. Additional energy was needed for growth, however, when all the wheat bran, wheat middlings, and ground oats were replaced. Soybean meal with corn distillers' byproducts replaced the dried skim milk, fish meal, and meat scrap with satisfactory results in starting rations. The dried distillers' solubles did not equal dried skim milk on an equivalent riboflavin basis, but dried semisolid sirups did replace dried skim milk, indicating possibly some loss of nutritive value in the process of drying solubles.

The Maryland station found that bacterial synthesis of riboflavin occurs in the feces of chickens. Chickens kept on the floor will, in the absence of normal amounts of riboflavin in their rations, apparently eat enough of their feces to supply the deficiency and thus maintain a reasonable level of hatchability. Hatchability of the eggs from birds in wire cages on a riboflavin-deficient ration decreased markedly within 1 month, whereas that of the pullets on the floor continued to be unaffected for a period of 2 years.

MINERAL SUPPLEMENTS FOR LIVESTOCK

Further contributions have been made on how to maintain proper mineral balance in livestock feeding, particularly with reference to providing adequate amounts of phosphorus, the most prevalent mineral feeding problem throughout the country.

Common range grasses in southern Texas are too low in phosphorus to meet the requirements of beef cattle, as shown in tests by the Texas station in cooperation with the Department. A supplement of either bonemeal or disodium phosphate improved the performance of the cattle, particularly in increased calf crop, greater number of calves weaned, and higher weaning weight of calves. No additional advantage resulted from feeding a more complex mineral mixture containing besides bonemeal, iron, copper, manganese, cobalt, zinc, and boron, indicating that the trouble in this area was solely a phosphorus deficiency. Phosphorus deficiencies were also met by increasing the content in range grasses through application of superphosphate as a fertilizer.

Calves fed mainly on native mountain-meadow hays, which were found to be high in calcium and low in phosphorus and yielded highly alkaline ash residues, suffered various ill effects in studies at the Colorado station. When the hay was treated by spraying a phosphoric acid solution to increase the phosphorus content of the ration from 0.1 to 0.2 percent, much less trouble was encountered at calving time, especially with young heifers calving the first time, and calves were more thrifty. Yearling steers fed on hay so treated consumed about twice as much hay per head during the wintering period as in previous years and showed better hair coats and over-all "bloom," indicative of general thriftiness.

In a search for suitable sources of phosphorus to replace bonemeal in chick rations, the Washington station found that defluorinated rock phosphate or superphosphate fines could be used satisfactorily, pro-

vided the percentage of phosphorus in the ration was increased slightly.

The Kentucky station found defluorinated rock phosphate equal to bonemeal as a source of phosphorus for growing chicks, but raw rock phosphate containing 3.49 percent fluorine resulted in decreased feed consumption, with a corresponding retardation in growth rate. A mixture of calcium metaphosphate and calcium carbonate was slightly inferior to either bonemeal or defluorinated rock phosphate but much superior to raw rock phosphate, as measured by growth and appearance of the chicks.

Similarly, a defluorinated phosphate (containing 0.10 percent fluorine) and a colloidal phosphate (containing 1.80 percent fluorine) proved as satisfactory as steamed bonemeal as sources of phosphorus for growing chickens at the Indiana station. The addition of as much as 15 percent of wheat bran and 10 percent of wheat middlings did not improve the basal ration. This indicated that the phosphorus supplied by the bran and middlings was not utilized by the chick so far as rate of growth is concerned.

Steamed bonemeal and defluorinated superphosphate gave almost identical results when used by the Texas station as sources of phosphorus in broiler rations. As much as 3 percent of defluorinated superphosphate was used with no bad effects. The presence or lack of an animal-protein feed did not influence the comparative efficiency of either material.

The Maryland station found the phosphorus of amorphous calcium metaphosphate available to chicks, while that of calcium pyrophosphate was totally unavailable.

A current problem for poultrymen is the relative scarcity of oystershells, formerly used to furnish calcium. The New Jersey station has found that limestone in the form of grit or flour or both is a practical substitute.

Cobalt deficiency.—A deficiency of cobalt in dairy cattle was recognized in northeastern Wisconsin by the Wisconsin station. Animals afflicted show poor appetites, reduced milk production, and reduced hemoglobin levels in the blood. Feeding cobalt as a sulfate in salt at the rate of 1 ounce to 100 pounds of salt corrected the deficiency as reflected by slow rise in hemoglobin and restoration of appetite and milk production.

Iodized salt.—When fed to bred gilts with steamed bonemeal, iodized salt was markedly superior to plant salt and steamed bonemeal, as shown by pig-production records of the Indiana station. Larger litters, heavier birth rates, greater vigor at birth, fewer still-born pigs, and larger litters of heavier and stronger pigs at weaning time, with a total lower death loss, occurred when iodized salt was fed as a supplementary source of iodine.

IMPROVING THE PRODUCTIVITY OF LIVESTOCK THROUGH BREEDING

The application of scientific breeding methods is resulting in the production of improved lines of farm animals, as measured by rigid production tests.

A breeding project of the New Jersey station has indicated the possibility of improving the production of dairy cattle by inbreeding and line-breeding, accompanied by rigid selection. In 12 years the experimental Holstein herd average has been raised from 8,500 pounds of

milk testing 3.7 percent to 12,000 pounds of milk testing 3.9 percent. The primary contribution of the work rests in the development of superior inbred sires having marked prepotency for transmitting desirable growth, type, butterfat content, and production.

Under the coordinated regional swine-breeding investigations in which a number of midwestern stations and the Department participated, distinct progress has been achieved in the development of improved inbred and crossbred lines of swine.

Typical of these are the experiments at the Iowa station, where 60 litters of cross-line pigs obtained by crossing purebred inbred lines have excelled uncrossed purebreds, sired by the same boars, in size of litters, gains in weight, and survival of pigs to 5 months of age. Cross-line litters contained, on an average, 1.8 more pigs when 5 months old. The cross-line pigs weighed on an average 0.4 pound more at birth, 4.8 pounds more at weaning time, and 28.6 pounds more when they were 5 months old.

The Minnesota station developed a number of promising new inbred lines of swine. These included seven inbred lines of Poland China hogs and a superior line known as Minnesota No. 1 that originated from crossing the Danish Landrace with the Tamworth breed, with subsequent inbreeding. Another line was started by crossing Poland Chinas and Yorkshires. A number of cross-line litters from inbred lines of Poland Chinas have given outstanding performance both in rate of gains and efficiency of feed utilization.

In six generations of selective inbreeding with Duroc-Jersey hogs at the Alabama station the average feed requirement per 100 pounds of gain has been reduced from 386 to 334 pounds.

Similarly, the Idaho station, through 4 years' intensive breeding of Poland China hogs, increased the average daily gains from 1.13 to 1.39 pounds and decreased the average feed requirement per 100 pounds of gain from 420 to 393 pounds.

As many as five desirable characters affecting egg production, namely, early maturity, high winter intensity, nonpause, nonbroodiness, and high persistency, have been combined by the Massachusetts station in a population of Rhode Island Red chickens. While the complex mode of inheritance made this task a painstaking and time-consuming one, notable progress was made over a 10-year period.

Through 5 years of intensive breeding and selection the Pennsylvania station has obtained a strain of White Holland turkeys which produce an average of about 100 eggs per year, or nearly double that of the average turkey hen in Pennsylvania. Through improved feeding and management practices, which include artificial lighting for both toms and hens and the addition of an ample amount of riboflavin to the ration, the hatchability of eggs has been increased to over 68 percent, as compared with a hatchability of 22 to 25 percent in this flock at the beginning of the experiments. These accomplishments point the way to a more profitable turkey industry in the State.

Good progress was reported by the New Jersey station in the development of a new small-bodied, broad-breasted, buff-colored turkey of good market quality, designated as the Jersey Buff. This accomplishment has been attained within a period of 3 years. While further standardization of this new variety of turkey is still in progress, considerable breeding stock already has been released to New Jersey poultrymen.

ARTIFICIAL BREEDING AS A MEANS OF IMPROVING ANIMAL PRODUCTION

The practice of artificial insemination as a means of greatly extending the use of high-quality proved sires and reducing the cost of sire service has expanded rapidly in recent years, particularly among dairy farmers in the Northeast.

Improved methods of handling semen for shipment and for artificial breeding of dairy cattle scattered over all sections of New York has greatly increased the usefulness of good dairy bulls with proved ability to transmit high milk-producing characteristics to their daughters. Recent work by the New York (Cornell) station has shown that semen from the bulls can be diluted even more than had been previously, so that from a single bull service 40 to 80 or more cows can be bred instead of 20. Recently a single service from 1 bull was enough to breed 87 cows. There were no significant differences in the fertility obtained from the semen of 6 bulls diluted at rates ranging from 1 part of semen to 50 parts of egg yolk-citrate buffer solution. Also, after 4 days' storage there were no significant differences in conception rates.

The New York (Cornell) station has also found that a rapid test for quality of semen based on the rate at which semen diluted with yolk-citrate diluent will reduce a dilute solution of methylene blue is very useful in estimating the quality of bull semen. Under standard conditions the test was shown to be largely dependent upon the concentration of the spermatozoa, their motility, and the concentration of ascorbic acid in the semen, all of which appear to be important as indications of the potential fertilizing capacity of semen.

The value of adding gelatin to a yolk-phosphate diluent in prolonging the life of spermatozoa, as observed by the Ohio station, led to an investigation of various amino acids as desirable constituents of the diluent. Both glycine and *l*-proline proved highly beneficial in this regard.

Artificial insemination proved a practical and efficient method for breeding nearly 2,000 range cows over a period of 3 years, increasing greatly the potential number of calves per bull. The studies were carried on by the Missouri station in cooperation with this Department and the Indian Service of the Department of the Interior. Of the cows inseminated one or more times, 78.8 percent produced calves and required an average of 1.63 inseminations per calf. The Missouri station has also developed a simple staining method for the differentiation of live and dead spermatozoa in semen, which is a useful tool in evaluating semen quality.

KEEPING ANIMALS HEALTHY

Animal disease losses run into staggering totals each year. According to findings of the Inter-Asscoiation Council on Animal Diseases and Production approximately one-half of the colts, one-third of the pigs, one-fifth of the dairy calves, and one-fourth of the pullets die prematurely. Heavy death losses also occur among older animals, and further high intangible losses result from the decreased vigor and poor efficiency of animals suffering from various types of parasitism. Research has a noteworthy opportunity in developing ways to reduce these losses.

INFECTIOUS DISEASES

Sheep may be permanently immunized against black disease (infectious necrotic hepatitis) by a single subcutaneous vaccination with a 5-cubic centimeter dose of an alum-precipitated toxoid, according to a recent finding of the Montana station. This disease takes a heavy toll of sheep in certain areas when the animals become infested with liver fluke.

Continuing studies on the control of pulpy kidney disease (enterotoxemia) of lambs, the Oregon station found that antiserum prepared by hyperimmunization of horses with toxin from cultures of *Clostridium perfringens*, type D, isolated from lambs dead of pulpy kidney disease proved efficient in controlling outbreaks.

Tests at the Virginia station showed that certain cows may react to the johnin test without showing any clinical symptoms of Johne's disease (paratuberculosis). These animals may, however, spread infection to other susceptible dairy cattle, as illustrated by the case of a calf which had been negative to three johnin tests, but gave a positive reaction after 3 months' exposure in a pasture lot with reactor cows. The results point to the necessity of isolating reactor cows from the herd.

As an aid in interpreting the johnin test in cattle the Alabama station and the Department designed and constructed an instrument for measuring the skin thickness of cattle following intradermal injections of johnins, tuberculins, and other allergins.

Infectious calf scours responded favorably to therapeutic doses of sulfasuxidine and sulfathalidine in experiments by the Pennsylvania station. The sulfathalidine was apparently more bacteriostatic than the sulfasuxidine when given in equal dosages. Toxicity studies indicated that two to four times the therapeutic dose of the sulfonamides could be administered without evidence of toxicity. A histopathological sudy of the liver, spleen, and kidneys showed no tissue changes.

Similarly, sulfathalidine was effective both in the prevention and cure of diarrhea of newborn calves in trials at the South Carolina station.

In experiments at the New Hampshire station, a considerable proportion of cases of udder inflammation (mastitis) due to streptococcus in dairy cows was successfully cured by treatment with sulfanilamide in oil whether administered while the cows were giving milk or when they were dry. Good results were also secured with tyrothricin. When the inflammation was caused by staphylococcus germs, however, the results with both drugs were quite unsatisfactory. Injection with a staphylococcus vaccine gave no improvement.

Infections of the udder of young heifer calves following injury to the teats by the horn fly, *Haematobia serrata*, were shown by the Florida station to be a common cause of mastitis in young heifers, frequently resulting in blind quarters, fibroid and asymmetrical udders, deformed teat sphincters, and abnormal udder secretion when the heifers freshened.

A 5-percent suspension of silver oxide in oil was found to be an efficient therapeutic agent for removal of *Streptococcus agalactiae* from the dry udder, in experiments at the California station. A dry period of at least 8 weeks' duration is recommended so that sufficient time will be available to effect a cure. One month after silver oxide

in oil has been introduced into an udder a sample should be drawn for bacteriological examination, and if *S. agalactiae* is still present a second treatment should be given.

An outbreak of acute mastitis with toxemia in 11 of a herd of 33 dairy cows during a period of 10 days has been described by the Wisconsin station. The isolation of *Aerobacter aerogenes* from the secretion of 10 of the affected cows indicated that this type of udder infection can be particularly devastating in a dairy herd.

A condition clinically and pathologically similar to pregnancy disease in ewes has been found associated with vitamin A deficiency in a study at the North Dakota station. Many of the animals responded to vitamin A therapy by a disappearance of the ketosis within a few days and, when not in moribund condition, by improvement and in some cases the disappearance of the symptoms of pregnancy disease. These findings strongly indicate that vitamin A deficiency may be a predisposing factor in the production of ketosis in pregnant ewes.

Streptothricin, an antibiotic substance which the New Jersey station pioneered in developing as especially promising in the treatment of certain diseases of farm animals, may have important application in human medicine, according to recent reports. The station has determined the conditions for maximum production of streptothricin from *Actinomyces lavendulae* and has found it to be effective in high dilution against certain Gram-negative bacteria, both in culture and in vivo, and to have low toxicity to farm animals. Findings of medical research conducted elsewhere indicate possibilities for use of this antibiotic in the treatment of human infections caused by Gram-negative bacteria against which penicillin is not effective.

At the Illinois station chicks inoculated with *Salmonella pullorum* were given sulfa drugs mixed with the feed to determine the effect on survival. Of seven sulfa drugs used in this manner, two were outstanding in the prevention of mortality. In some cases mortality was decreased from 95 percent to as low as 1 to 2 percent.

In cooperative studies by the California station and the United States Navy, glycol vapors at very high dilutions were found to kill air-borne bacteria within a few minutes. One part of triethylene glycol in 600,000,000 parts of air was effective in killing *Salmonella pullorum*, as was also 1 part of propylene glycol in 2,000,000 parts of air. Present studies are directed toward the elimination of air-borne organisms in incubators and brooders, the major offenders in the spread of pullorum disease.

Of 17,000 birds in 5 flocks inoculated with a vaccine developed at the New Hampshire station, only 13 birds, all in 1 flock, contracted the disease variously called contagious indigestion, blue comb, or pullet disease, and only 5 died. These favorable results offer hope for eventual suppression of this disease, which is ranked as the second most costly malady of mature birds in New England, being surpassed only by range paralysis.

Detailed study by the Connecticut (Storrs) station of a disease complex caused by a virus and designated as avian pneumoencephalitis led to the conclusion that this disease is a distinct entity. Symptoms are described which permit differential diagnosis between this disorder and the more common avian encephalomyelitis.

Evidence that the ocular type of fowl leucosis is transmitted from affected hens by way of the egg, obtained by the Iowa station and the

Department, has suggested a practical control program for breeding flocks, based on frequent careful culling of all birds used for production of chicks.

INTERNAL PARASITES

Better control of internal parasites in farm animals is an important consideration in maintaining satisfactory livestock production. A great deal of research has centered on ways for most effectively utilizing phenothiazine, which is generally recognized as the most effective anthelmintic compound developed to date.

The California, Illinois, and Pennsylvania stations agree in the finding that mixing phenothiazine with salt at rates ranging from 1:9 to 1:15 and keeping such mixtures before sheep at all times is a simple and effective way of administering the drug. While some supplementary treatment may be required in case of extreme parasitism, this method has wide application and, according to the California station, "most nearly approaches the ideal anthelmintic of any of the drugs or methods employed."

The Illinois station has shown that phenothiazine can be successfully administered to sheep when incorporated in a pellet made from soybean meal.

Extensive studies by the Wyoming station on losses due to Sarcosporidia led to the conclusion that this little-understood group of parasitic one-celled organisms is of far greater economic importance in livestock production than is usually supposed. In the absence of other diseases, the symptoms of sarcosporidiosis include lameness, weakness, anemia, great emaciation, paralysis, and death. Biopsy or post mortem examinations are required to complete the diagnosis. Suggestions for prevention and control center around keeping the food and drink from contamination by feces of infected animals.

Various sulfa drugs proved effective against coccidiosis in different classes of animals in experiments at the Michigan station. Lambs given 1 gram daily of sulfasuxidine as a drench for 1 week showed a significant drop in the oocyst counts and a marked improvement in condition. Similar results were obtained when lambs were given 0.1 gram per kilogram of body weight of sulfaguanidine in grain for 6 days. It was necessary to start treatment early in the infection to obtain satisfactory results. Marked favorable response was produced in White Leghorn chicks affected with cecal coccidiosis by the use of a saturated solution of sulfamethazine as drinking water.

Poisonous plants.—A serious menace to livestock production under many conditions is the presence of poisonous plants.

The Florida station has shown that *Crotalaria spectabilis* is poisonous to cattle, hogs, horses, mules, sheep, goats, and chickens, especially in the fall, when it is green and succulent and other forage is dry and unattractive. Both the seed and the green, dried, or frosted foliage are toxic, and few animals that show clinical signs of poisoning recover. The toxic principle has been isolated, the greatest concentration being in the ripe seeds. The symptoms vary considerably in different species of animals, acute and chronic forms being noted. No cure is known.

Cattle pastured on wild Winter peas (*Lathyrus hirsutus*) while these plants were blooming and forming seed developed a rather typi-

cal acute lameness, in studies at the Alabama station cooperating with the School of Veterinary Medicine of the Alabama Polytechnic Institute and the Department. Steers grazed continuously on *L. hirsutus* as hay did not develop any untoward symptoms. A similar toxic effect of this plant on hogs had been reported earlier by this station.

Koa haole (*Leucaena glauca*) is an abundant and nutritious forage legume in Hawaii. It is widely fed to cattle, but swine, poultry, rabbits, horses, and mules lose their hair and exhibit other symptoms from eating it. The Hawaii station cooperating with the Minnesota station has isolated the toxic principle, mimosine, which occurs in the water-soluble fraction of seeds and leaves. It has been purified and its properties determined. The addition of soluble iron compounds to koa haole or synthetic diets containing mimosine renders these diets relatively nontoxic to rats. The application of these findings to the feeding of farm animals remains to be worked out.

IMPROVED MANAGEMENT PRACTICES

An adequate supply of good drinking water.—This is of great importance in successful livestock production. For example, trials at the Iowa station showed that high-producing dairy cows, while being watered by means of water bowls, drank approximately 18 percent more water and yielded 3.5 percent more milk and 10.7 percent more butterfat than while being watered twice a day at the outdoor tank. Another important finding from this trial was that the temperature of the water was not nearly so important as the temperature of the air. In other words, if the cow had to stand outside in near-zero weather, she was likely to drink relatively less regardless of the temperature of the water.

Highly mineralized water may be detrimental to animals. Abrupt changes from slightly mineralized to highly mineralized water may produce acute toxic effects and death in animals, according to findings of the Colorado station. Water mineralized in excess of 1 percent markedly retarded gains in experimental animals, which, after a 9-month period, were 6.5 percent or more below weights attained by animals receiving water mineralized to less than 0.1 percent.

A method of treating acid mine water with hydrated lime to render it safe and palatable for livestock has been developed by the West Virginia station. The necessary equipment consists of a pipe to carry mine water to the mixer, a barrel or other suitable mixing chamber, and a hose for siphoning water from the mixer to the watering trough. The neutralizer costs only about 1 cent per 75 gallons of water, and the labor cost at 25 cents per hour will be approximately 10 cents per 100 gallons of water. Farmers may find it cheaper to supply stock water in this way rather than to haul it long distances in dry weather.

Heat in farrowing pens.—Supplemental heat in farrowing pens has proved to be a simple and effective method of reducing losses among young pigs. Death losses in young pigs to 10 days of age averaged 46.2 percent among litters without heat but were 29.7 percent among litters provided with supplemental heat from electric lamps in trials at the Indiana station.

The importance of artificial lighting for poultry.—This means of stimulating higher winter egg production is widely recognized.

The Pennsylvania station found that turning on the lights in poultry houses increases egg production in winter but not because the hens have a longer time to eat. Lighting itself spurs egg production. The evidence from this research indicates that 10 hours per day permits ample feed intake, although it may not be sufficient for maximum egg production or egg weight. For maximum egg production, 12 to 14 hours of light per day seems best under practical farm conditions. No correlation was found to exist between light intensity and egg production, egg weight, or mortality when light intensity was varied from 0.5 to 38 footcandles.

Testing various sources of illumination which might be used on farms without electricity, the Oklahoma station found that Welsbach gaslights and mantle-type gasoline lanterns were satisfactory all-night lights for stimulating egg production of turkey breeding hens. A kerosene wick-type lantern was ineffective.

Various problems involved in high altitude incubation of chicken and turkey eggs were studied by the Wyoming station. Slight increases in temperature, humidity, and volume of air circulation in incubators at the high altitude (7,200 feet) as compared with normal values at low altitude proved effective in increasing hatchability. It is further recommended that when eggs are to be incubated at altitudes over 6,000 feet they should not be shipped from lower altitudes but should be produced in the neighborhood where the hatching is done.

Cannibalism.—Among flocks of chickens and turkeys, especially under crowded conditions, cannibalism frequently causes heavy losses. A device to prevent cannibalism was designed and constructed by the California station, which cuts off a portion of the upper beak and cauterizes at the same time to stop bleeding. As many as 250 birds per hour have been debeaked with the device. There seems to be no noticeable ill effects on the birds when the beaks are cut off.

IMPROVED PROCESSES AND NEW ANIMAL PRODUCTS

Maintaining quality in eggs.—Using an insulated water-cooled egg-storage cabinet, the Nebraska station observed that with well water at 55° F. eggs can be cooled from 90° to below 60° in about 3 hours. Previous studies indicated that fresh eggs promptly cooled and stored at 60° in moist air will keep well for about a week. With equipment of this type, the producer can use the cool water to keep his product in good marketable condition.

A flash heat treatment at temperatures above the coagulation point of albumin proved effective in preserving table eggs in experiments by the New York (Cornell) station. The eggs were exposed for 5 seconds in boiling water. As a result a thin protective film of coagulated albumin was deposited on the interior of the shell and was not visible on breaking the egg. Quality of eggs was superior to that of untreated held under like conditions.

Dipping eggs in oil containing a small amount of pentachlorophenol proved effective in maintaining quality in eggs during storage in trials at the Michigan station. Oil alone effectively reduced moisture loss during storage, and the addition of the pentachlorophenol was useful in controlling bacteria and molds, particularly when eggs were treated within 48 hours after being laid.

New developments in processing dairy products.—A troublesome bitter flavor frequently developing in raw whole milk or cream, particularly during the winter months, is due to the break-down of the butterfat through action of the enzyme lipase, according to findings of the New York (Cornell) station. It has been shown that milk from individual cows varies in this respect, so that this trouble in mixed herd milk may be corrected by rejecting the milk from certain cows identified as offenders. Prompt cooling of the milk on the farm and constantly holding it at low temperatures help to prevent this defect, while allowing cold milk to become warm and then recooling it greatly accelerate bitter flavor development. Shaking the milk also increases this reaction. Pasteurization of the milk inactivates the enzymes and thus prevents further reaction.

Cultured buttermilk of improved flavor has been experimentally produced by the Montana station through the addition of 0.15 percent of citric acid crystals to the milk culture before inoculation. The addition of the citric acid favors the development of acetylmethylcarbinol plus diacetyl, the principal flavor constituent of butter, which imparts the more desirable flavor in the cultured buttermilk. This simple procedure offers a way of increasing consumer demand for this wholesome product, which, for economy, should be encouraged.

By a process developed by the Pennsylvania station a new frozen concentrated milk may be manufactured in any dairy plant that is equipped with an evaporator, homogenizer, and ice-cream freezer. The process consists of evaporating, as for canning; freezing to a mushy consistency in the ice-cream freezer; further freezing in a storage room at 10° below zero after packaging; and storing at low temperatures. It is defrosted and diluted to fluid consistency by putting the frozen block directly into hot water. By using an equal amount of water, a product resembling coffee cream or cereal cream is produced. By adding twice as much water, milk for beverage or general purposes is produced.

The Florida station has found that 2 to 2½ percent of wheat flour greatly improves the physical characteristics of ice cream which contains less than the customary amount of milk solids, thus pointing the way to maintaining the volume of ice cream in the face of reduced available supplies of milk solids.

Pasteurization of milk for cheese making by direct steam proved practical in experiments by the New York State station. A dilution of the milk of 10 percent or less had little effect on curd strength, and the effect of higher dilution could be corrected by proper use of cheese culture. This process provided a way for the manufacturers of better quality cheese in plants unable to obtain conventional pasteurizing equipment because of wartime restrictions.

The use of larger than normal amounts of rennet, washing the curd, and careful control of curing temperature were the most important steps in the method for producing a good-quality southern short-cure Cheddar cheese developed by the Texas station. The best cheese produced within a 4-week period was ripened for 2 weeks at 45° F. and 2 weeks at 60°. The best cheese produced within an 8-week period was ripened 2 weeks at 45° and 6 weeks at 60°.

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PROMOTING BETTER NUTRITION

The program of food production is indirectly augmented by improved methods of food preparation and preservation designed to conserve not only the food itself but its nutritive values as well. Beyond this, dietary habits, whether self-chosen or imposed, play an important part in determining how effectively the food supply will meet the nutritional needs of the people. These phases of nutrition research thus become matters of concern to those planning to promote better nutrition, whether for the family, the community, the armed forces, or whole population groups. Experiment station research has continued within the year to supply practical guidance in these nutrition problems, and it is timely that the results of the various studies be summarized. Because of the particular importance of this phase of the work in aiding the war effort, food and human nutrition investigations are discussed at length in this report at the sacrifice of work bearing on other problems of interest to the homemaker.

NUTRIENTS IN FOOD

Food, always of particular interest in wartime, has assumed an important place in war and post-war plans. The emphasis now as compared with that in World War I has changed, however, for it is not enough to supply sufficient food to meet merely the caloric or energy demands of an army or a population. The food supplied must be of such nutritive quality that it will also furnish adequate amounts of the many dietary factors now known to be essential for health and well-being. In making definite plans for feeding the armed forces and our own and allied civilian populations, it was recognized that there were many gaps in our knowledge of the distribution of vitamins in foods and of the influence of various factors on these and other nutritive qualities of foods. There was need for an intensive program to study these problems, and many laboratories therefore directed their research toward food investigations. Much of this research was conducted in continuation of the National Cooperative Project Conservation of the Nutritive Value of Foods, noted in the 1943 report (p. 73).

SCOPE OF INVESTIGATION

Foods studied.—Not fewer than 40 of the State experiment stations and the Hawaii station have responded with data covering a wide variety of foods and various food constituents. Included on the list are about 35 of the common vegetables; about 10 of the common fruits; some wild greens and fruits; fruits and vegetables and a few prepared foods commonly grown or used in Hawaii but not generally available on the mainland; cereals and cereal products, particularly rice, oats, and wheat; meats, including pork, beef, lamb, turkey, and prepared variety meats; milk and butter; and honey.

Nutrients determined.—A few studies were made of protein quality and of the minerals calcium, phosphorus, and iron; most of the studies, however, dealt with the vitamins, since they are the substances most influenced by production factors and methods of preparation. Carotene, the various B vitamins, and ascorbic acid all

received attention, but in fruits and vegetables ascorbic acid was studied more extensively than the other vitamins.

Problems investigated.—Most of the stations studied the foods that are important crops in their own regions. Some were concerned with the vitamin content of foods just as harvested or obtained, confining the interest, for example, to commercially important crops and products, to local wild plants of nutritional promise, or to foods used or potentially available in local feeding programs. The latter type of survey was carried out by the Hawaii station, which investigated a long list of foods commonly grown or used in Hawaii to determine the content of carotene, thiamine, and ascorbic acid. The findings have been exceedingly useful in planning the food program of the islands, isolated as they have been and dependent on their own food resources. Many of the Hawaii-grown foods analyzed are of tropical or oriental occurrence, and the data concerning them may be useful as applied to the native foods our fighting forces may find and utilize in Pacific areas.

Most of the stations were concerned with factors affecting nutritive values, for previous research had shown (1) that foods as grown are subject to many natural variations and (2) that natural foods as harvested or produced are subject to change in vitamin values in particular, in storage, and in the course of processing or cooking procedures.

To bring together all the data obtained for all the foods studied and to discuss all the findings of the stations on the various phases of the food-value problem is not possible within this brief report. The scope of the work has been outlined above, however, and in the paragraphs that follow selected studies will be discussed to show how various factors may affect food values and to indicate what practices will aid in the conservation of nutritive properties.

CONSERVATION OF FOOD VALUES BY THE RIGHT SELECTION FOR MATURITY AND RIPENESS

Picking at the right stage of maturity and ripeness may yield returns not only in eating quality but in vitamin values as well. Some vegetables and fruits gain in vitamin value as they mature or ripen. **Peppers,** for example, are rich in both carotene and ascorbic acid when they are at the mature green stage, but as they turn red they show a remarkable increase in both of these vitamins, as demonstrated by results obtained at the Georgia and Rhode Island stations. The pimiento peppers grown at the Georgia station and harvested early in the season averaged about 1.9 mg. of carotene and nearly 200 mg. of ascorbic acid per 100 gm. In pimientos harvested late in the season, after frost, the ascorbic acid value increased by more than 50 percent. The 10 varieties of peppers grown at the Rhode Island station and harvested at the green stage were not so rich in carotene and ascorbic acid as the Georgia-grown pimientos, averaging only about 0.4 mg. carotene and 136 mg. ascorbic acid per 100 gm. of the green peppers. As the peppers turned red, however, the vitamin values greatly increased—carotene to an average of 13.1 mg. per 100 gm. and ascorbic acid to 202 mg. per 100 gm.; these were increases of 3,175 percent and 49 percent, respectively.

Carrots are also a good source of carotene. They should not be harvested as baby carrots or be allowed to grow too old, if vitamin value is to be realized, according to results obtained at the

Rhode Island and Arizona stations. At the Rhode Island station the 10 varieties tested consistently increased in carotene content as they matured, reaching a maximum of about 6 mg. per 100 gm. in about 90 days after planting, after which they slowly decreased in carotene value. Similar results were obtained in trials with 2 varieties grown on experimental farms at the Arizona station. The concentration of carotene in these carrots increased with size, the smallest containing only 2 mg. per 100 gm., as compared with 20 mg. per 100 gm. in the older roots. These carrots were poor sources of thiamine, containing but 0.04 to 0.07 mg. per 100 gm., and there was no constant relationship between thiamine content and size, age, maturity, or length of growing period. Differences in ascorbic acid content with maturity were slight, but nonmarketable carrots of pencil size contained 5 to 8 mg. per 100 gm., as compared with 3 to 6 mg. per 100 gm. in carrots of marketable size.

In a detailed study at the Missouri station it was found that green **snap beans** harvested at an immature stage were higher in carotene and in riboflavin but lower in thiamine and nicotinic acid than those harvested when more mature. Harvested when the seeds were large (14 mm. or more in length), the whole beans—seeds and pods—were markedly lower in carotene, slightly lower in riboflavin, but appreciably higher in ascorbic acid, thiamine, and nicotinic acid than the young snap beans; but when the pods of these overmature beans were discarded as inedible, the "fresh shelled beans" remaining were low in carotene, ascorbic acid, and riboflavin, but were good sources of thiamine and nicotinic acid. This marked decrease in carotene value with approaching maturity was observed in snap beans and lima beans tested at the Indiana station.

Turnip greens of two varieties (Shogoin and Seven Top) were grown at five of the southern stations (Georgia, Louisiana, Mississippi, Oklahoma, and Virginia) and at the Virginia Truck Experiment Station in a cooperative study of factors affecting the ascorbic acid content of the greens. In these trials, nitrogen fertilization did not significantly affect the ascorbic acid content, but maturity differences did. Greens of both varieties harvested in the late stage of maturity contained more ascorbic acid (on the wet basis) than those harvested at the early stage. Apparently these changes were due to a decrease in the moisture content of the greens as the plants matured.

Whether fully ripe **tomatoes** will contain more or less ascorbic acid than pink ripe or green ones may depend upon the conditions under which they are ripened. Studies at the Louisiana station indicate that ripening in extremely hot sun may have an adverse effect on the vitamin content of tomatoes. In the fall, for example, field-ripened tomatoes, grown in Louisiana, were richer in ascorbic acid than the green ones, but in June when the sun was very hot tomatoes ripened in the field contained less ascorbic acid than the green ones, and no more than those that were picked slightly pink. Tomatoes are poor sources of thiamine and riboflavin, but, at that, there were slight losses of these vitamins when the tomatoes were ripened in the sun. Maturity and ripening conditions, probably associated with cultural and later with storage conditions, no doubt accounted for the low ascorbic acid values found by the Massachusetts station in the tomatoes on northern markets in late-winter and early-spring months. These tomatoes contained only about one-third as much ascorbic acid as field-

ripened samples, and this point should be kept in mind in using fresh tomatoes found in northern markets in winter.

CONSERVATION OF FOOD VALUES IN STORAGE

Once harvested, vegetables tend to lose their vitamins, and this loss is more or less rapid, depending on the vegetable and the way it is handled. The importance of refrigeration for **lima beans** was shown in a cooperative study by several of the southern stations (Georgia, Mississippi, South Carolina, Virginia, and USDA Vegetable Breeding Laboratory). The shelled beans held for 48 hours at 40° F. (ordinary refrigerator temperature) lost approximately 20 percent of their ascorbic acid, whereas at room temperature they lost about 69 percent; it proved better to hold the beans in the pod, for the vitamin loss was less rapid, amounting to only 23 percent in 96 hours in the refrigerator or 68 percent at room temperature. **Snap beans,** freshly picked, were wrapped in paper and placed in the refrigerator without delay in tests at the Illinois station. Analyses after 24 and 48 hours showed that these beans had lost none of their ascorbic acid, while other beans from the same lot but held out in the room lost 30 percent of their original ascorbic acid. This loss in vitamin value, typical of vegetables that stand in the market or the kitchen, was also observed in **okra** (Louisiana station), which lost approximately half of its ascorbic acid if held 24 hours at room temperature but about 20 percent if held at refrigerator temperature.

For vegetables, such as cabbage and the root vegetables, that may be stored for comparatively long periods, proper attention to storage conditions will help to maintain nutritive value as well as quality. Cold storage of **cabbage,** as observed in cooperative studies by the Ohio and Illinois stations, served to prevent any appreciable ascorbic acid loss in 1 or 2 months. Losses of ascorbic acid occurred in the third month, however. Cabbages taken out of cold storage at the end of 2 months could be held for a week in the refrigerator without showing any loss in ascorbic acid, but if held at room temperature distinct loss was observed within 3 days.

Studies of New York-grown Smooth Rural **potatoes,** held at about 40° to 50° F., and North Dakota-grown Irish Cobblers, held in a root cellar or in commercial storage, showed that storage losses of ascorbic acid amounted to about 50 percent within a month or 6 weeks. These losses continued in storage, not more than about 30 percent of the vitamin being left after 7 months in the New York (Cornell) tests at 50°, and not more than 6 to 10 percent after 5 months in the North Dakota storage experiments. Storage tests at the Minnesota and Nebraska stations likewise showed that continuous losses of ascorbic acid occurred throughout storage. The loss was more rapid in potatoes held at 35° than in those held at 40°, and the latter in turn lost their ascorbic acid more rapidly than did potatoes stored at 50°. By April, however, all the potatoes had lost such a large part of their ascorbic acid that there were no marked differences between lots stored at the different temperatures.

Sweetpotatoes, on the other hand, retain their vitamin values remarkably well in storage. This was demonstrated in studies at the Louisiana station, where the varieties tested were found to retain from 60 to 70 percent of their ascorbic acid even after 7 months' storage

(October to May) at 60° to 80° F. Varietal differences in ascorbic acid tended to become less significant after storage, since varieties with higher initial ascorbic acid suffered greater losses of the vitamin in storage. These results were borne out in similar studies at the Georgia and North Carolina stations, where no significant loss of carotene was shown in 168 days of storage of sweetpotatoes of the Porto Rico variety.

Among the fruits studied for storage losses, **cantaloups** and **watermelons** received attention as part of the Arizona study to determine the nutritive value of foods as actually consumed in Army and Navy training groups at the University of Arizona. As was expected from previous work, cantaloups proved an excellent source of ascorbic acid in the diet, and it was found further that they were also excellent as a source of carotene. The ascorbic acid values varied widely, from 25 to 62 mg. per 100 gm., and maturity differences and storage losses were found to account in part for this variation. Held in the refrigerator the cantaloups became flatter in flavor and in 1 week lost 8 percent of their weight (chiefly because of moisture loss from the rind) and 20 percent of their ascorbic acid; in 2 weeks they lost 11 percent of their weight and 25 percent of their ascorbic acid. Holding the cut cantaloups, and likewise cut watermelons, on the cafeteria counter for as long as 2 hours after being cut didn't decrease the ascorbic acid content; likewise, pieces of watermelon left over from 1 day's meal could be held in the refrigerator till the next day (20 hours) without any loss of ascorbic acid. The watermelons proved to be low in ascorbic acid and carotene, but this was partly counterbalanced by the fact that they were served in large pieces.

Experiments at the North Carolina station showed that fresh, bottled **milk** left on an open porch on a fairly warm day (60°–72° F.) for half an hour lost almost a third of its riboflavin; in 2 hours it lost two-thirds of this vitamin, and in 2½ hours almost three-fourths of it. The same rapid destruction of riboflavin by sunlight was observed in trials at the Idaho station, where 70 to 80 percent of the vitamin was found to be destroyed when the milk bottles stood outdoors in the sunshine for 6 hours on a cold day (41°). In good shade or in brown bottles only about 10 percent was lost. The waxed paper cartons now commonly used for packaging milk afforded even better protection and kept the riboflavin loss down to 8 percent.

CONSERVATION OF FOOD VALUES IN SELECTION OF EDIBLE PORTION AND KIND OF PRODUCT

In these days when more than ever it is essential to fight food waste it is important to guard against throwing away some of the nutritive values paid for in food "as purchased." **Oranges,** for example, are commonly reamed and only the juice is used as the "edible portion"—in fact, often only the strained juice. This is a wasteful practice, according to the findings of the Arizona station, for it not only increases the amount of the orange discarded as refuse but also results in throwing away more of the ascorbic acid, the vitamin for which the citrus fruits are particularly valued. The experiments with navels, sweet seedlings, and Valencias showed that oranges prepared as segments always contribute more than those prepared in any other manner. Usually, slicing gives better ascorbic acid value than juicing, and unstrained juice contains more of the vitamin than does the strained

juice. The strained juice is the least economical method of serving, since it contains only from one-half to three-fourths of the amount of ascorbic acid contained in the segments. This same relationship also holds for **grapefruit,** as shown by the results with the Marsh variety. The Arizona tests were carried further to show that orange juice held in the icebox 24 hours after the fruit has been reamed retains most of the ascorbic acid originally present in the fresh juice; on an average, not more than 5 percent is lost.

In the preparation of foods for table use there are many more instances where attention should be given to trimming and selection of edible portions to conserve vitamin-rich parts frequently discarded. It is well known, for example, that the outer green leaves of cabbage and lettuce are richer in vitamins and minerals than the inner bleached leaves; and **broccoli** leaves, so the Indiana station found, are much richer in carotene than are the flower heads and stems. These facts suggest the desirability of using the very green leafy parts. Often, however, the outermost leaves are tough and bitter and must be discarded in spite of their high vitamin values. Another alternative for cabbage and lettuce would be to select, where possible, the loose or open-headed greener varieties. The facts supporting this suggestion, for lettuce, at least, were obtained at the Rhode Island station, where of the 10 varieties of **lettuce** tested, the 2 loose-leaf varieties Black Seeded Simpson and Grand Rapids were the greenest and the highest in carotene and contained three to five times more ascorbic acid than the crisp-head lettuce varieties; the butter-head varieties which stayed relatively green were intermediate.

Wild greens are especially good as sources of carotene and ascorbic acid. Dock, pigweed, wild mustard, lambsquarters, and Russian-thistle are particularly rich in these vitamins, according to analyses by the New Mexico station, while dandelion, purslane, and sowthistle are less rich. Wild greens showing up well in a Florida study of their vitamin values were lambsquarters, pokeberry, *Crotalaria spectalilis*, and coffeeweed. Dandelions and fiddleheads (ostrich fern) compared favorably with cultivated greens in riboflavin values obtained in analyses by the Maine station. Rose hips from wild roses growing in New Mexico proved to be exceedingly high in ascorbic acid.

Sometimes the trimming away of vitamin-rich portions takes place before the housewife ever buys the food. This is always the case if she buys highly milled cereals, for the outer layers of the grain, the parts richest in the B vitamins, are removed in the milling process. The Arkansas station, continuing work on the vitamins in products of commercial **rice** milling, found that not only the thiamine was reduced, as previously reported, but also the riboflavin and nicotinic acid in milling the brown rice to give the white polished head rice sold for human consumption. In the process brown rice lost 50 percent of its riboflavin and 66 percent of its nicotinic acid, the lost vitamins remaining in the rice bran and rice polish. These results were in agreement with those obtained by the Louisiana station, where Arkansas- and Louisiana-grown rices were found to lose 66 to 87 percent of their vitamin content in going from the brown to the polished form. According to the analyses, the byproducts, rice bran and rice polish, were excellent sources of the B vitamins, and the brown rice a good source of all but riboflavin. This suggested the desirability of using brown rice rather than the white rice and, further, of using rice polish

to enrich quick breads. Indeed, biscuits with this additional enrichment, using 1 part of rice polish to 3 parts of enriched flour, were found, in the Louisiana experiments, to contain more than twice as much thiamine as biscuits made from enriched flour alone. In the baking process both types of biscuits retained about 82 percent of the thiamine value of the dry ingredients, with the source of thiamine (from the rice polish or the commercial enriching ingredient of the flour) apparently having no influence on the degree of retention.

Rolled **oats** for the morning's cereal have almost the same content of B vitamins as the oat groats (hulled oats) from which they are made. This conservation of vitamin values was demonstrated in work by the Wisconsin station which showed that rolled oats obtained from various mills contained almost as much of the B vitamins (thiamine, nicotinic acid, pyridoxine, pantothenic acid, and riboflavin) as the oat groats used as the raw material. Analyses of many other breakfast cereals obtained on the open market by the Wisconsin station indicated that the present-day system of enriching cereal products with synthetic vitamins or vitamin concentrates serves to make them, even if highly milled, more nearly like the whole grains in vitamin value. This is particularly true if the enrichment is carried to the point of essentially restoring to the cereals the vitamins removed in the branny layers in the course of milling. The Wisconsin workers found in particular that the thiamine values for practically all the corn, oats, and rice products were within the range of values for whole grains, and that very few of the riboflavin values fell below the lowest for the whole grains.

CONSERVATION OF FOOD VALUES IN COOKING

To obtain a better understanding of cooking losses, primarily for the purpose of showing what practices permit the best retention of food values, as well as flavor and attractiveness, many of the experiment stations investigated the factors affecting these losses.

Small-scale experiments with vegetables conducted under conditions comparable to those met with in home-cooking practice showed in general that some of the vitamins originally present in the raw vegetable might actually be destroyed, that some would pass into the cooking water and be lost if that were discarded, and that the rest would be retained by the cooked vegetable. Carotene and the B vitamins, including thiamine, riboflavin, and nicotinic acid, were found to suffer relatively little if any destruction. Ascorbic acid, however, usually underwent some destruction amounting at times to only a few percent but under unfavorable conditions to as much as 50 percent or more. Since the B vitamins and ascorbic acid are water soluble, they dissolved to a considerable extent in the cooking water. How the various cooking conditions operated to influence the amount of a particular vitamin destroyed, dissolved, and retained by the vegetable may be illustrated by a few selected examples.

Extensive investigations of the nutritive value of green **snap beans,** conducted by the Illinois, Michigan, Minnesota, Missouri, North Dakota, and South Dakota stations, included a study of cooking losses by four of the stations. It was found in experiments at the Missouri station that carotene and the B vitamins—thiamine, riboflavin, and nicotinic acid—were not appreciably affected by cooking for periods

as short as 20 minutes or as long as 3 hours, but ascorbic acid was less stable, and as much as 50 percent of it was destroyed in 3 hours' cooking. Some of the ascorbic acid and the B vitamins went into solution, so that discarding the liquid from the cooked beans caused a marked loss of these vitamins. In general, the findings at Missouri were borne out by the work of the other stations.

The retention of ascorbic acid in the boiled beans was shown by the Illinois tests to depend upon the amount of water and the cooking time. Thus, cut beans boiled in half their weight of water for 15 minutes retained 78 percent of their ascorbic acid; doubling the amount of water decreased the retention to 66 percent; and doubling the cooking time as well as the amount of water decreased the retention to 56 percent. With the decrease in the amount of the vitamin retained in the vegetable there were consistent increases in the amount dissolved and the amount actually destroyed in cooking. If the beans were left whole, as was done in independent tests at the Virginia station, an increased volume of cooking water did not increase the cooking losses of ascorbic acid.

The use of a little baking soda to preserve the color of frozen **lima beans** during cooking did not appear to have any significant effect on vitamin C losses according to results obtained at the Utah station, where samples of the frozen beans were cooked in tap water with and without the addition of sodium bicarbonate. The added soda increased the pH of the cooking water from 6.7 to 8.3, decreased the cooking time from 17 to 15 minutes, and preserved the normal color of the beans, but did not increase the cooking loss, since both lots of beans retained (in the beans plus the cooking water) about 75 percent of the ascorbic acid originally present in the frozen lima beans.

The effects of various home-preparation and cooking practices on the ascorbic acid value of **cabbage** were observed by the Illinois, Minnesota, and Ohio stations in work conducted as part of the National Cooperative Project. Cooked in not more than twice its weight of water, cabbage was found to retain from 50 to 75 percent of its ascorbic acid, but in a large volume of cooking water (about four times the weight of the cabbage) the losses to solution were greatly increased and the cooked cabbage retained only 30 to 55 percent of the ascorbic acid originally present in the raw vegetables. Vitamin retention was also favored by cooking in a covered pan for short periods only (about 10 minutes or, at the most, not more than 25 minutes).

Cooked cabbage held over hot water to keep it warm, as if being held for later serving, lost 70 to 80 percent of its ascorbic acid in 1 hour and as much as 90 percent in 2 hours. Since the freshly cooked cabbage contained only about 50 percent of the ascorbic acid it had when raw, the final retentions were very low. When the cooked cabbage was held in the refrigerator 2 to 3 days and then warmed up, the reheated cabbage retained about 24 to 32 percent of the ascorbic acid originally in the raw vegetable. Cabbage shredded with a sharp knife and held in air for 1 hour or in water for from 1 to 3 hours lost but little of its ascorbic acid.

Whereas cabbage cooked under favorable conditions retained at least 50 to 75 percent of its ascorbic acid, **chard** and **beet tops** showed much lower retentions than this in the lots cooked at the Michigan station. In these tests the chard cooked 21 to 22 minutes in a covered

pan with only the water left clinging to the washed leaves retained only 5 to 8 percent of its ascorbic acid and the beet greens only 16 to 17 percent. Cooked to the same state of doneness as in the above tests, by plunging the leaves into rapidly boiling water and cooking for 7 to 8 minutes, the chard retained 12 to 26 percent of its original ascorbic acid content and the beet greens 25 to 35 percent. The lower retentions by the first method of cooking were attributed to the longer cooking time required.

The advantage of putting greens on to cook in boiling water was illustrated by results with **turnip greens** obtained in a rather extensive study by the Alabama station of ascorbic acid in raw vegetables and of factors (storage, cooking, sun-drying, dehydration) influencing their ascorbic acid content. Turnip greens put on to cook in about their own weight of cold water and cooked for 30 minutes from the time boiling began retained only about one-third of their ascorbic acid, whereas greens put into boiling water and cooked for 30 minutes after boiling was resumed retained three-fourths of their ascorbic acid. **Asparagus** tips and **green beans** cooked by these two methods also retained more of their ascorbic acid when started in boiling water.

Spinach cooked in a covered pan with only the water left clinging to the washed leaves retained 60 percent of its original ascorbic acid content in studies carried out at the New York (Cornell) station. This retention is greater than that obtained for chard and beet leaves in the Michigan tests but smaller than that for the cabbage (Ohio tests) cooked in minimum quantities of water. The investigations with spinach, like those with chard and turnip greens, showed that greens put on to cook in boiling water and cooked rapidly to doneness retained more of their vitamin value than those started in cold water then brought to a boil and cooked to doneness. Other investigations at the New York (Cornell) station showed that increasing the quantity of cooking water decreased the quantity of ascorbic acid in cooked **broccoli** and spinach (and decreased also the thiamine and riboflavin in the latter) but seemed not to affect the amount lost from **asparagus.**

Cooking losses of ascorbic acid in **potatoes** were studied in tests conducted at the Nebraska and Illinois stations. The several varieties of the Nebraska-grown potatoes were washed, scraped, cut in half lengthwise, and boiled in a small amount of water in a covered pan for 20 to 30 minutes until done. Cooked in this fashion they retained about 87 to 91 percent of their ascorbic acid. In standing for only 15 minutes after cooking, ascorbic acid decreased to about 79 percent of the raw value. Appreciably smaller retentions, averaging about 73 percent of the raw value, were obtained when the potatoes were cubed before boiling. Potatoes that were mashed and sampled at once retained about 65 percent of their raw value; in 15 minutes of standing the retention dropped to 62 percent.

In the Illinois tests, peeled, halved Chippewa potatoes retained 87 to 88 percent of their ascorbic acid when boiled and about the same amount with steaming or cooking in a pressure saucepan. Holding the pared potatoes 1 to 3 hours in water before cooking did not significantly affect the vitamin values. Keeping the boiled potatoes in the refrigerator for 24 and 70 hours resulted in additional losses of 40 and 70 percent of the ascorbic acid. Potatoes baked in their skins retained about as much of their ascorbic acid as did boiled potatoes, but if over-

baked they retained somewhat less, and if peeled before baking they retained only about 78 percent of their ascorbic acid. Investigations at the Idaho station showed that the most important factor in determining the ascorbic acid value of baked potatoes was the promptness with which they were eaten; standing at room temperature after baking they lost 33 percent of their ascorbic acid in one-half hour, about 50 percent in 2 hours, and 100 percent in 4 hours.

Sweetpotatoes grown and tested in cooperative trials at the Georgia and North Carolina stations were found to retain their carotene and their ascorbic acid very well either in boiling or in baking, provided the skins were left on in the cooking process. In cooking tests with a number of the varieties the Louisiana station found that pared sweetpotatoes cooked by boiling in water, either plain or slightly sweetened, by steaming in a pressure saucepan, and by baking and boiling without paring retained from 69 to 83 percent of their original ascorbic acid value. The highest retention was in a pressure saucepan; the lowest, in boiling after peeling; the presence of sugar in the boiling water exerted a favorable effect, however, and resulted in a 74-percent retention.

From the studies that have been selected to illustrate the nature of cooking losses it is apparent that vegetables vary greatly in the tendency to retain their vitamin content in cooking, and that any one vegetable will vary in behavior, depending on the manner of cooking. No hard and fast rules can be given for the best cooking procedures to be followed in all cases for retaining vitamin values, but the studies reviewed suggest the following practices as being generally helpful: (1) Avoid the use of a large quantity of cooking water; (2) bring the water quickly to the boiling point—even have the water boiling when greens are put in to cook; (3) use preferably a covered pan; (4) cook quickly for the shortest time necessary to attain doneness (particularly guard against overcooking in a pressure saucepan; (5) cut vegetables no smaller than necessary to effect ready cooking to doneness; and (6) serve at once.

The retention of vitamins in cooking rib roasts of **beef** was studied by the Montana and Texas stations. While their findings differed in detail, they were in agreement in indicating that in roasting the beef retained approximately 50 to 75 percent of its thiamine, 80 to 97 percent of its riboflavin, 75 to 80 percent of its nicotinic acid, and 75 to 90 percent of its pantothenic acid. The studies showed that the raw rib roasts from different animals varied in their vitamin content to begin with; according to the Texas findings, however, raw rib roasts within a carcass did not show significant differences. The retention of thiamine and pantothenic acid was significantly lower in well-done than in rare roasts, but this difference was not shown for riboflavin and nicotinic acid (Texas station). The Montana work suggested tentatively that the thiamine and riboflavin values for grass-fed animals were slightly higher than those for grain-fed (barley) animals.

Cooking losses in **pork** were investigated by the Kansas, Minnesota, North Carolina, and Wisconsin stations. All were agreed that wide variations were to be expected in the actual vitamin content of cooked pork samples since the raw pork showed wide variations not only from carcass to carcass but between different cuts and even between different parts of the same cut. Loin roasts and chops, the latter cooked by roasting and braising, and fresh and cured hams as roasts

and as fried slices were included among the several studies. The results when summarized showed that the different cuts variously cooked retained from 55 to 85 percent of the thiamine originally present in the raw pork, from 75 to 85 percent of the riboflavin, and from 80 to 85 percent of the nicotinic acid.

Lamb and **veal** and **variety meats,** including meat organs, tongue, Canadian bacon, and pork link sausage, were analyzed before and after cooking at the Wisconsin station. Roasting, broiling, braising, stewing, and boiling were included in the cooking procedures. Lamb and veal varied considerably in the vitamin content of the raw cuts. When roasted or broiled they showed thiamine, riboflavin, and nicotinic acid retentions similar to those for the beef and pork.

When the data from all the studies are assembled without regard to the kind or cut of meat they give an interesting picture of how well the different vitamins are retained in meat by the various cooking processes. Such a summary is presented in table 1. Although the figures must not be taken as final and the conclusions must be considered as only tentative, the indications are as follows: (1) Of the B vitamins studied, riboflavin suffers the least destruction in cooking, with from 65 to 100 percent retained in the meat; nicotinic acid is almost as well retained (50–100 percent); and thiamine suffers the most destruction, with from 20 to 95 percent retained; (2) of the various cooking methods broiling permits the best retention of vitamin values, followed in decreasing order by frying and roasting (possibly about on a par), braising, and stewing (or boiling).

TABLE 1.—*Percentage vitamin retention in meats by various cooking methods*

Method	Thiamine	Riboflavin	Nicotinic acid
Broiling	70–95	80–100	80–100
Frying	86	77	85
Roasting	50–75	75–97	75–80
Braising	20–60	75	50–60
Stewing (boiling)	25	65–80	50–55

The amount of the vitamins found in the drippings varied from almost none to as much as 20 percent of that originally present in the raw meat. The loss to the drippings seemed to be associated in part with the presence of water and with the surface exposed in proportion to the weight of the cut. In stewing, appreciable amounts of the vitamins went into the "gravy," but destruction in cooking was high, so that stews as a whole retained relatively low proportions of the original meat vitamins.

NUTRITIONAL SURVEYS

Effective use of knowledge concerning nutrients in foods calls for more information on the nutritional needs of the people. These needs are revealed by nutritional surveys which in their broad scope involve dietary surveys concerning eating habits, biochemical analyses of body fluids to determine the earliest effects of these eating habits, tests to determine whether body functions are becoming deranged because of dietary deficiency, and clinical tests to observe any anatomical changes resulting from continued deficiency. Experiment station research in human nutrition reported within the year has been

concerned with one or more of these various phases of a nutritional survey.

DIETARY HABITS AND BLOOD VALUES

Nutritional status of rural youth in Oregon.—In a study extending from 1942 to 1944, grade- and high-school children in five counties in Oregon were asked by experiment station investigators to keep records of the number of servings of all foods eaten by them during a week. Some of these children were given blood tests for hemoglobin and ascorbic acid. The separate reports for the different counties all showed hemoglobin values well within the range considered normal. In four of the five counties the lowest individual readings were found among the high-school girls and the highest among the high-school boys. Although there is not a simple relationship between the hemoglobin of the blood and particular foods in the diet, it is of interest that the average consumption of meat, fish, and poultry in the different counties amounted to more than one serving a day, and that eggs were eaten on an average of from 3.3 to 7.0 times a week, and dried peas and beans from 0.9 to 1.5 times a week.

The blood ascorbic acid values of the majority of the children in the survey were below 0.60 mg. per 100 cc., the lowest level recognized as adequate by the Committee on Vitamins of the American Academy of Pediatrics. In two of the counties these low ascorbic acid levels were associated with low intakes of citrus fruits and other raw fruits, tomatoes, and green leafy vegetables.

Nutrition and the blood picture of college students in Mississippi.—During the September physical examinations of Mississippi college students, examinations of the blood of 684 men and 604 women, all apparently healthy, showed that the red-blood cell counts were practically normal but that hemoglobin levels of 7.2 percent of the men and 17.2 percent of the women were below the level considered as the minimum for normal subjects. This blood picture, with the hemoglobin below normal, although not markedly so, and red cell count normal, was suggestive of an anemia associated with undernutrition.

Dietary habits of rural and urban high school girls.—Dietary records kept for 1 week during 1939 and 1940 by more than 500 high school girls in Kansas and Minnesota as part of the cooperative nutritional status project of the North Central States, referred to in earlier reports, were analyzed to show (1) the frequency of use of the various food groups and (2) the mean daily intakes of the various food essentials by age.

The first analysis showed certain dietary deficiencies (according to accepted standards) varying in degree in the two States and possibly suggesting minor regional differences in food habits. Meat was more generously used by the Minnesota than by the Kansas girls, only 10 percent of the former as compared with more than 25 percent of the latter reporting less than one serving a day. Only 12 percent of the Kansas and 8 percent of the Minnesota girls ate one or more eggs daily. The number reporting no servings of milk was small but in Kansas more than one-half and in Minnesota nearly one-third of all of the girls had less than one serving of milk a day. Potatoes were eaten more frequently by the Minnesota than by the Kansas girls, with 67 percent of the former and only 43 percent of the latter having one or

more servings daily. Less than one serving daily of green and yellow vegetables was reported by more than 80 percent of the Minnesota and almost 90 percent of the Kansas girls.

According to the second analysis, the diets furnished fewer calories than the recommended daily allowances of the Board of Food and Nutrition of the National Research Council, particularly in the 13- to 15-year-old group. Protein failed to meet the standard allowances for the 13- to 15- and 16- to 20-year-old girls. Calcium was markedly below the allowances at all ages and reflected the low milk consumption. Iron, with a mean value of 12.2 mg., was below the NRC allowance of 15 mg. for these age groups. Vitamin A, with a mean value of 5,982 International Units, was well above the allowance of 5,000 I. U. but individual subjects had values much below it.

Planned and self-chosen diets of college girls.—The self-chosen diets of 36 girls in a cooperative dormitory on the agriculture campus of the University of Nebraska were analyzed from accounts kept during 2 months in the fall and 2 in the spring for the quantities of the different food groups used per person per week, in comparison with the recommendations of the Bureau of Human Nutrition and Home Economics for a low-cost adequate diet.

The quantities of foods purchased were less than half the Bureau recommendations for potatoes and dried beans, peas, and nuts; approximately two-thirds for the leafy green or yellow vegetables, eggs, meat, and cereals; and somewhat more than the recommended amounts for tomatoes and citrus fruits, other fruits, and other vegetables. When the nutritive value of the diet was compared with the NRC standard allowances, the greatest discrepancy was found to be in calories, which came to only 72 percent of the allowance. The diet was somewhat low in protein, adequate although slightly less than optimal in calcium, adequate in vitamin A, nearly adequate in niacin and ascorbic acid, and generous in thiamine and riboflavin.

In another phase of the study menus for 6 months for a group of eight girls were planned from one of the BHNHE market lists for adequate low-cost diets to provide the NRC standard allowances for girls from 16 to 20 years of age when the selected foods were eaten in quantities furnishing 2,000 calories, and this diet was compared with the self-chosen diet for the same period of another group of 12 girls. The average cost at 1942–43 prices was $1.69 per person per week for the planned, and $2.10 for the self-chosen diet. The greatest savings in cost came from the use of unprepared rather than prepared cereals, potatoes in generous quantities, inexpensive table and cooking fats, and very little bought desserts, salad dressings, and condiments. However, the girls on the planned diet felt better satisfied with their menus than previously and did not eat between meals as much as the other group. Biochemical analyses of the blood and urine and dark adaptation tests made on all of the girls in this phase of the study gave slightly better values for vitamin A and much higher thiamine values for the group on the planned diet, but otherwise the results were similar for the two groups, and there were no marked differences between the two groups in health and good spirits.

Food supplies and diet of Texas rural families.—A dietary survey made by the Texas station in the spring and summer of 1942 of 400 rural families distributed in three regions of the State indicated that there was a satisfactory supply of protein-rich foods for 77 per-

cent of the families, of vitamin A sources for 85 percent, of vitamin B complex for 87 percent, and of ascorbic acid for 67 percent in out-of-garden season and 97 percent during garden season. Owners had the most excellent food supply and laborers the least. White groups were better supplied than Negroes, and the Northwest better supplied than the other two regions. Food habits revealed by this Texas study showed great improvement during the 15-year interval between an earlier study of the diet of Texas school children and the present study. This was particularly true of the use of milk, butter, eggs, leafy vegetables, and whole cereal preparations.

VITAMIN METABOLISM AND REQUIREMENTS

Dark adaptation and vitamin A requirements.—In the vitamin A requirement studies of the Rhode Island station noted in the 1943 report (p. 78), 5,500 I. U. daily appeared to be more than enough to maintain a satisfactory state of dark adaptation in three college women studied for several months. The results of further studies designed to get closer to normal requirements, suggested that 5,000 I. U., the NRC-recommended allowance for both men and women, was barely adequate for the two women subjects who participated and inadequate for the men. The data also suggested a relationship between body weight and vitamin A requirements.

Ascorbic acid metabolism and requirements.—In an extension of the studies at the New York (Cornell) station on vitamin C metabolism in preschool children noted in the 1943 report (pp. 78–79), daily ascorbic acid intakes of 23 to 25 mg. were not enough to maintain tissue saturation in the eight children studied. The utilization of the ascorbic acid was increased by addition of potassium citrate in amounts proportional to the content of the salt in orange juice. When orange juice was substituted for ascorbic acid and potassium citrate, there was even better utilization of ascorbic acid. From these studies it would seem that a natural source of vitamin C, such as orange juice, is preferable to ascorbic acid for children.

A small number of students participated as subjects in an investigation at the Tennessee station to determine the quantity of ascorbic acid necessary to maintain maximum levels in the blood plasma by increasing the intakes at 2-week intervals until no further rise in the concentration of the vitamin in the blood plasma resulted. On 32 to 35 mg. of ascorbic acid daily, the lowest level tested, there was a gradual decrease in the concentration of the vitamin in the blood plasma. This is of interest in view of the present tendency to consider even 30 mg. of ascorbic acid an adequate daily intake. For 8 of 12 subjects, a daily intake of 82 to 85 mg. gave as high plasma levels as found later in a much higher intake, 107 to 110 mg. Urinary excretion tests given to three subjects who had shown differences in plasma ascorbic acid levels on the same intake suggested a direct relationship between requirement and body weight, with adequacy at about 1 mg. of ascorbic acid per kilogram body weight.

Vitamin D and calcium retentions.—Following up the calcium-balance study of the north-central cooperative nutritional status study noted in the 1943 report, the Ohio and Kansas investigators repeated the tests with six subjects supplementing the diets, in which the calcium intakes were adjusted to different levels by different amounts of

milk, by 500 I. U. daily of vitamin D. On less than 0.8 gm. of calcium, the amount found necessary for equilibrium in the earlier study, there was no improvement in calcium retention; at higher levels there was some evidence of improved retention but so slight as to be of no significance, leading the investigators to conclude that "the well-selected diet provides for the vitamin D need of the young adult."

IMPROVING DIETARY PRACTICES

School lunches.—Some of the benefits to be derived from well-planned school lunches, together with corrective treatments for diagnosed deficiencies, have been demonstrated by the Florida station in a study which has extended over 3 years. More than 1,000 children in 9 schools in 2 counties of the State were given physical examinations and blood tests for anemia and vitamin A deficiency; the breakfasts and suppers at home and lunches at school of more than 600 children attending 6 of these schools were evaluated; and the effects of corrective measures for anemia, better food in the school lunch and nutrition education of the children and parents on the health of the children in 2 of the schools were demonstrated in comparison with a third in which no measures were taken.

Recommendations of value in school-lunch planning for rural communities have been made available by the South Carolina station as an outcome of the study noted in the 1943 report (p. 80). These include a basic weekly lunch guide showing the special contributions of certain foods toward meeting the requirements of the various food essentials, actual menus as served, forms for classroom food records and diet score cards, procedures to be followed in weighing and measuring, and policies which should govern school lunchrooms.

Suggestions for adequate family diets.—From a study of the food habits and nutritive adequacy of the diets of 38 relief families in Honolulu, the Hawaii station suggested that a more adequate diet on a limited food budget could be obtained by certain shifts in money expenditure for different food groups. Ten simple suggestions were offered for improving the diet in various respects, and common errors in food buying were discussed.

Recognition of the difficulty of altering traditional habits of food preparation led the Mississippi station to a study of the methods generally used in one region by white and Negro owner and cropper families for preparing 12 foods common to the region. Customary practices in the lowest economic group studied included the frying or long cooking of foods or the use of soda, vinegar, or other ingredients to make the foods tender and shorten the time of cooking; the use of water rather than milk and eggs in making various hot breads; and the infrequent use of salads. Possible changes suggested include more general use of pan broiling in place of frying, increased use of raw leafy vegetables and fruits in the natural state without extra preparation, and better recipes for soups and stews using canned tomatoes as an ingredient.

The importance of a willingness to make some adjustments in food selection as to the use of new foods and food combinations and to reduce waste has been emphasized by the Ohio station in a report on wartime shifts in utilization of food and feed. Using production data from United States Department of Agriculture Bureau of Agricultural

Economics, the author predicts that the basis of the civilian dietary of the future will be milk solids, eggs, enriched bread and cereals, green leafy and yellow vegetables (together with Victory garden produce), fruits, potatoes, dried beans, peas, and nuts, and limited meats, especially of the high-quality cuts.

IMPROVED METHODS OF FOOD PRESERVATION

Comparative studies of various methods of preserving foods and of types and varieties most suited to one or another method of preservation make possible more efficient planning in production and processing. As an illustration, the Oregon station, in an effort to increase the variety and amount of foods for the armed forces in form suitable for wide climatic conditions, tested many methods of canning, freezing, dehydration, and other processing forms. This involved not only the testing of methods of processing but also the production of suitable varieties. For example, several hundred thousand experimental strawberry selections were tested for adaptability to freezing, only to find that of these just three were outstanding when the product was frozen whole. The experimental work on the dehydration of vegetables played an important part in Oregon's sale of 3½ million dollars worth of dehydrated vegetables in 1943–44.

In response to popular request, the Montana station brought up to date and extended the directions previously issued for the preservation of vegetables grown in Victory gardens. Each vegetable was considered separately with regard to the methods found satisfactory for its preservation. For some this meant directions for canning, freezing, brining, canning in acid and brine, and dehydration, and for others only one or two of these methods.

DEHYDRATION

Construction of dehydrators.—Of the dehydrators constructed for experimental evaluation, one built by engineers at the Pennsylvania station was unique in that it employed electrical energy in the form of infrared heat as the energy for dehydration of food. Tests conducted with an experimental-type dehydrator indicated that such an apparatus, which could easily be designed for commercial scale, was a reasonably practical answer to the dehydration problem. One of the most interesting discoveries was that the interior of food pieces dried by infrared energy attained a temperature higher than that at the surface, thereby hastening the drying operation and eliminating the disturbing effect of case-hardening.

General principles.—Experience in small-scale or commercial dehydration has led to the formulation of certain general practices that must be followed for successful production of dehydrated products. Stations that in the past year have been particularly interested in this phase of food conservation, notably California, also Oregon and to a lesser extent Arkansas and New York stations, have discussed these practices with particular emphasis on one or another of the important factors. In general, the recommendations call for the selection of strictly fresh raw material in prime condition; selection of varieties adaptable to drying; proper preparation for drying, including blanching and, in some cases, sulfiting or treatment with antioxidants; rapid dehydration accomplished under controlled temperatures and by

making the pieces as small and the tray loads as light as practicable; reduction of moisture content to very low levels (to as low as 2 percent and usually below 5 percent in commercial practice, but not quite so low in home dehydration); proper packaging in moisture vaporproof containers; storage in a cool place; and, finally, rehydration of the product by soaking preliminary to cooking.

Experience of the California station with cabbage, potatoes, and onions indicated that treatment of these vegetables with a sulfite spray or dip before dehydration gave dried products of better color and flavor and permitted the use of drying temperatures of 20° F. or more above those in commercial use, thereby speeding up production. Sulfiting also greatly prolonged the storage life of dried products and rendered them less liable to heat damage through carelessness of workmen in the final stages of drying. Palatability studies on home-dehydrated vegetables by another group of California workers showed that all vegetables were more palatable if blanched long enough to destroy peroxidase. Most of the dehydrated vegetables improved somewhat in palatability when soaked from 1 to 3 hours before cooking.

Testing the material for moisture content toward the end of the dehydration process or after storage in the equalizing bins is a necessary step in large-scale plant operations. Since moisture determinations by the standard chemical method are time consuming and more exact than necessary for control work, the New York State station investigated the merits of several rapid methods, including ones employing commercial moisture-testing instruments. As a result of these trials, two such methods, requiring about 1 and 2 minutes per sample, respectively, are recommended for speed and satisfactory accuracy. Another method, developed at the Michigan station, is based upon the fact that while moisture is being evaporated from the material the temperature of the exhaust air is considerably lowered. The less the difference in temperature between the air entering the dehydrator or the equalizing bin and that being exhausted, the more nearly dry is the product. A simple device for measuring this temperature differential and practical application of the method were developed.

Storage at low temperatures seemed essential for maintaining satisfactory flavor and color of many dehydrated vegetables in California and New York (Cornell) studies. Low temperature, however, was not necessary for maintaining stored dehydrated foods at low moisture content, although it did play an important part in maintaining moisture levels in stored frozen foods, according to findings of the New York State station. With dehydrated foods, the protective wrapper was very important in preventing absorption of moisture; in order to maintain a moisture level sufficiently low to retard spoilage by micro-organisms, a protective wrap having a moisture vapor transmission rate of less than 0.3 gram of moisture vapor per square meter was found necessary if the stored foods came in contact with an atmosphere of 70 percent relative humidity or over.

Varieties suitable for dehydration, problems, and special products.—Not all varieties of a given vegetable are satisfactory for dehydration. This was brought out by varietal adaptability studies of some 12 vegetables at the New York State station; of carrots, cabbage, onions, and tomatoes at the California station; and of carrots at the Texas and Michigan stations. Although some varieties may be of a

satisfactory quality, they are ruled out commercially because of low harvest yield. In California, for example, the best quality of dehydrated cabbage was obtained from the Savoy variety, but its harvest yield was low, leaving Danish Ballhead and Hollander as the only varieties available.

In Texas experiments with carrots, they were prepared for blanching and dehydration by lye peeling and washing, this process resulting in preparation losses of 28 to 37 percent. Lye peeling was also preferred in the Michigan tests, since the dehydrated products remained clear and bright in appearance in contrast to the white flaky surface of abrasion-peeled or hand-pared carrots. Blanching and treatment with bisulfite before dehydrating were recommended by the California station for getting high quality in dehydrated carrots. Carrot crumbs prepared at the Michigan station by grinding the carrots and drying them down to less than 2 percent moisture were ground to a powder; this could be reconstituted, using 4 tablespoonfuls of the powder to 1¼ cups of water, to give a product equal to canned pumpkin in texture. From there on, carrot pie was made in the same way as fresh or canned pumpkin pie.

Dehydrated potatoes have presented a storage problem in that they tend to darken appreciably in dehydration or in storage. This effect seems to be associated with the enzymes active in the peeled potato so that the general practice has been to blanch potatoes at high enough temperatures for a long enough time to inactivate these enzymes, particularly the peroxidase and catalase. Chemical tests are commonly carried out on samples of the blanched potato to see if these enzymes have been destroyed; if they can't be detected, it is assumed that the dehydrated potato will keep without darkening. Practical tests at the California station have recently cast doubt on the value of these enzyme tests, for some samples blanched enough to prevent darkening during drying still showed the peroxidase test, and other samples not showing the catalase test still darkened in processing. It is considered, therefore, that the color of dehydrated potatoes is a better index of their keeping quality than are the enzyme tests. Blanching at 170° to 175° F. or, better, at 190° to 200° completely prevented discoloration in the dehydrating process and gave relatively satisfactory keeping quality. A more effective and simple treatment for preventing the discoloration was immersion of the peeled potatoes for a few seconds, before dehydration, in dilute bisulfite solution (0.3 to 1.0 percent sodium bisulfite or metabisulfite) or dilute SO_2 or sulfite solutions. Tests at the Maine station also showed this sulfite treatment to be fairly effective in preventing darkening of dehydrated sound potatoes during storage. The sulfite treatment was not effective, however, in preventing the darkening associated with the brown cavities sometimes occurring in potatoes or the dark spots developing when potatoes come in contact with iron or bronze in the processing equipment.

This difficulty with darkening was not reported as occurring in the process developed by the Idaho station, wherein the washed potatoes were first baked (1 hour at 400° F.), then hand-peeled while hot, the inner portion being riced, and this and the peels dried separately for 4 to 5 hours at 150° to a final moisture content of 5 to 7 percent. The baking resulted in increased yields with about 70 percent of the dried material as potato shreds and 30 percent as peels for stock feed. This

new process not only saved waste but also eliminated a troublesome problem of waste disposal.

Among the fruits, dehydration experiments were conducted on apples at the Maryland station, where low moisture content and high SO_2 content were found to be the two most important factors in the retention of color, and on cherries at the Oregon station. The latter work, carried out in a special research program for the Quartermaster General's office to obtain cherries for more variety in the diet of troops, resulted in development of a suitable dehydration process for cherries. Further work is now under way to determine the dependability of this material for overseas use in hot climates.

In a study of factors affecting the properties of reconstituted dried eggs, the Iowa station determined that low moisture content (less than 2 percent in accordance with Army specifications) greatly improved the keeping quality of dried egg with respect to odor and flavor, thickening power, solubility, fluorescence, and color. Removal of reducing sugar by fermentation also improved keeping quality, but off-flavor sometimes resulted. Adjusting the pH of the liquid egg to 5.5-6.0 prior to drying improved keeping quality of the yolk portion.

A scrapple that dehydrated successfully and that did not turn rancid readily was prepared after experimental trials at the California station. It was made from cooked ground lean pork (not over 20 percent fat), polenta-grind corn meal, water, and only salt and pepper as seasoning. After cooking and molding, slices were cut, spread on trays, and dehydrated at 155° F. for 5 to 6 hours. Compression to about 60 percent of the original volume was found possible and is recommended for saving storage and shipping space. Palatability tests showed that the dehydrated scrapple, which may be eaten in the dehydrated form or reconstituted, is much preferred to dehydrated ground pork, either raw or steamed.

FREEZING

Commercial and home freezing equipment.—To meet popular demand, the Georgia station offered a revised bulletin on preserving foods by freezing, based on research work of the station and on observations of practical locker operation. This bulletin contained much of the information previously summarized, but was extended in many details. Emphasis was given to services that should be included in the operation of the locker plant for increased economy and for most effective staggering of input and outtake; and a new section on home freezers and a short one on commercial freezing were added.

The use of home freezing cabinets was only fairly begun when the war practically stopped their production, but thousands of existing cabinets were converted and reconditioned for frozen foods in the home. These home freezers, the Georgia station advises, should maintain a temperature of 0° F. throughout the year, and should have sufficient refrigeration to hold within 5° of zero even when being loaded to 10 percent of capacity load with unfrozen foods. Thus, the freezer should act both as a freezer and as a holding unit for frozen foods.

In a practical handbook on freezing foods for home use, prepared on the basis of previous instructions and additional research, the Minnesota station pointed out that many old ice-cream cabinets

originally designed to maintain a temperature of about 10° F. are being used for frozen-food storage. Such cabinets are not well suited to hold a temperature of 0°, but may be used with good success if held within a range of about 4° to 7°. Included in the Minnesota bulletin is rather extensive information on packaging and wrapping, the importance of this operation being stressed in order to minimize moisture loss and prevent freezer burn and to guard against oxidation and resultant rancidity changes.

Observations on the performance of single-compartment farm freezing and storage cabinets by the New York State station indicated that freezing of food on horizontal plates is more rapid than freezing on vertical plates. A preliminary survey of farm freezing cabinets in use showed them to average about 24 cubic feet per five persons served. Frozen food units for home use tested by the Indiana station were found to be satisfactory if equipped with rapid-freezing facilities sufficient to maintain temperatures of 5° F. or lower. There was no apparent deterioration in quality of foods in such units when held for at least a year. An allowance of 6 cubic feet of storage space per person was adequate to care for all the foods suited for freezing storage. A better interior arrangement of units seemed necessary in order that the food wanted could be found more easily.

As an aid to the locker operator handling wrappers to meet the needs of his patrons, the New York (Cornell) station summarized the fundamentals of packaging meats, poultry, fruits, vegetables, and eggs, pointing out in particular that gas-tight, moistureproof packages are necessary to prevent deterioration in quality of frozen foods during storage. To meet popular demand, the Kansas station revised and brought up to date their publication on preserving foods in frozen lockers. A third edition of this circular was published at the request of frozen food locker companies in Kansas and surrounding States, 10,000 copies being paid for by the companies for distribution to their patrons.

Attaining quality in frozen foods.—Mindful of the anticipated post-war expansion of freezing as a process of food preservation, a number of stations have concerned themselves with factors assuring the production of high-quality goods. The research has emphasized the importance of using raw products of prime quality, and, with fruits and vegetables, of choosing varieties adaptable to freezing, and of blanching them properly. Proper wrapping, packaging, and storage are essential for all frozen products. From experience in freezing late spring and summer fruits and vegetables, the New York State station concluded that a wide range of fruits and vegetables lend themselves to this method of preservation and that for vegetables blanching is an essential step in the procedure in order to prevent off-flavor developments and successfully preserve color and vitamins. In studies of varieties of Wyoming green vegetables desirable for freezing, the Wyoming station found that cultural conditions, disease, and insect pests affect the quality of the vegetable crop so that the same variety may yield better frozen products from some crops than from others.

The amount of juice draining from frozen fruit upon thawing is reduced by the use of pectinate in the preparation of the fruit for freezing. This effect was attained in tests by the New Jersey station with strawberries, raspberries, red cherries, and peaches. The pec-

tinate mixed with the sugar was sprinkled over and mixed with the prepared fruit, which was frozen as a dry-sugar pack and stored at 0° F. Apparently the pectinate combined with the calcium of the fruit to form a protective pectinate gel on the surface of the fruit. This prevented excess drainage of juice and improved the appearance of the fruit. Moreover, fruit thus prepared could be used directly in the preparation of jellied products; the short heating required gave the jellied products a better flavor than that of ordinary pectin jelly products.

Quality in frozen peaches was found by the Texas station to depend upon their texture, flavor, color, and rate of oxidation (brown discoloration and off-taste). With these qualifications in mind, 11 out of 35 varieties of peaches, all Texas-grown, graded excellent as frozen peaches, 11 graded good, and 13 only fair. The brown coloration was successfully controlled by dipping the peeled fruit, either sliced, quartered, or halved, in a solution containing 1 level teaspoonful of thiocarbamide in 1 gallon of water; after excess solution drained off, the fruit was packed in containers, allowed to stand for 2 hours to permit penetration of the thiocarbamide, then covered with sugar sirup and frozen. This browning of peaches in the process of preparation for freezing was controlled in tests at the Mississippi station by holding the peeled fruit under water, if holding was necessary, before slicing and packing in syrup; 1 teaspoonful of lemon juice per pint of water afforded additional protection against browning. Of the 16 varieties tested, 8 gave satisfactory frozen products, and of these the Elberta ranked first in quality.

Sweetpotatoes were successfully frozen at the Georgia station by a process that involved a preliminary cooking of the peeled sweetpotatoes under steam pressure to an internal temperature of 190° F., followed by pulping or slicing, treatment of the pulp or slices with 0.2 to 0.4 percent citric acid to prevent darkening, rapid freezing, and storage at 0°. The process gave a very satisfactory product and also proved economical since the puree could be prepared, frozen, and stored for 6 months for about 7 cents per pound. Other products successfully frozen as precooked foods included pumpkin, rutabagas, and tomatoes.

Successful storage of raw tomatoes in freezer lockers was accomplished at the Pennsylvania station by wrapping them individually in cellophane and freezing, without blanching, in air at −40° F. or in brine at −30°. Such tomatoes kept well and when partly thawed had the flavor of fresh tomato juice. The skin of the tomatoes burst uniformly in a ring at the largest circumference and peeled off cleanly. The flesh lost its firmness on thawing so that the fruit could not be sliced.

Frozen beefsteaks and pork roasts were thawed by several methods, at the Kansas station. The results of the tests indicated that thawing at room temperature, at refrigerator temperature, and at oven temperature gave similar results, although both steaks and roasts thawed at oven temperature were slightly less tender and required longer cooking than those thawed by the other two methods. Total cooking losses for the steaks thawed at the several temperatures averaged about 20 to 22 percent and for the roasts about 32 to 34 percent.

Workers at the New York State station concluded from their investigations that salt stimulates oxidation in ground meats, result-

ing in rancidity. Other seasoning materials, however, seemed to have a beneficial effect in retarding rancidity development. It is recommended, therefore, that pork sausage and ground beef to be quick-frozen and held in freezing storage should not contain salt in the seasoning mixture, although sage, pepper, mace, and ginger may be used. It was also found that ground pork should be frozen as soon as practicable after slaughter, as the longer it is held before freezing the more quickly it becomes rancid (oxidized) in frozen storage.

CANNING

Venting pressure cookers.—One of the problems arising in canning vegetables is that of proper venting of the pressure cooker. There is not, however, complete agreement of opinion on this question. One view, as expressed by the New York (Cornell) station, on the basis of its studies, is that a venting time of 10 minutes for a small-size (11-quart) pressure canner may be unnecessarily long for long-cooked vegetables, thereby resulting in further overcooking them. The Massachusetts station recognizes this as a valid criticism, but warns that—

> with many of the present practices in pressure canner operations, a reduction in process time would be dangerous, and increased amounts of spoilage could be expected because of the reduced safety margin of the process.

Safe processing of home-canned meats.—In the interest of safe processing of home-canned meats without too long a processing period, the Texas station recommends (1) heating the meat after packing in the jars, but before sealing, in order to drive out the air and provide a partial vacuum in the sealed can, and (2) processing for the shortest time possible to destroy the spores of *Clostridium botulinum*. The method developed to accomplish these ends carried the following instructions: Pack the meat cold and steam (without sealing) for 30, 60, 90, 60, and 80 minutes, respectively, for No. 1, No. 2, and No. 3 cans and pint and quart jars; after steaming, seal immediately, put hot, sealed containers immediately into a hot pressure cooker, and begin processing as quickly as possible; process these cans and jars for 50, 60, 85, 60, and 75 minutes, respectively; let pressure on gage return to 0; cool the tin cans quickly and thoroughly in cold water, but allow glass jars to remain undisturbed in the open cooker until the liquid inside stops bubbling; then finish cooling in the air at room temperature.

Quality in canned cherries.—The factors involved in the retention of quality in canned cherries, particularly as indicated by color, were investigated by the Michigan station. For best retention of quality over a storage period of 9 to 10 months, it was found that the cherries should be used as soon as possible after picking and preferably soaked in cold running water for 3 hours before pitting; that the cherries packed in hot, thoroughly sterilized glass jars should be covered with boiling-hot, 40- to 45-percent sirup (leaving a ¼-inch air space at the top of the jar); and, following partial sealing, be processed for 25 minutes in a boiling water bath followed by completion of the seal and cooling. The final phase, which was of great importance for color retention, was storage of the cooled jars in a cool, dark, dry place. A low storage temperature was found to be very important for maintaining quality.

New asparagus packs.—On the commercial basis, the California station developed and recommended some interesting new variations for asparagus. One was packing the asparagus, not in the usual brine, but in the juice extracted from the stalks discarded in trimming. This process resulted in increased firmness, richness of flavor, and ascorbic acid content. Another variation involved acidification of the juice or the regular brine with not less than 0.6 percent citric acid to give pleasing packs, with a distinctly tart taste.

Quality in home-canned snap beans.—Conserving both quality and ascorbic acid in home-canned snap beans was the object of canning experiments carried out at the Wyoming station. The texture of the canned beans which had been packed raw and exhausted in the can rated on a par with and for some varieties was found superior to those which had been given a precook of 5 minutes before packing and processing. Most of the raw-packed beans had a characteristic flavor that was normal and pleasant. This held true for such varieties as Red Valentine, Stringless Green Pod, and Tendergreen, which are mild in flavor, although some varieties, strong in flavor, might not be so desirable when packed raw. Incidentally, a greater amount of ascorbic acid was conserved in the raw-packed than in the precooked beans.

BRINING AND SALTING

General principles.—This old method of preservation has been revived, with improvements for home and industrial use. As a method of emergency preservation, it requires the minimum of labor and critical materials and offers the possibility of storing large quantities of vegetables in bulk. The salt, as the New York State station explained, acts first to preserve and second to draw water and sugar out of the vegetable so that bacteria can act on the sugar to form acid, which also acts as a preservative.

In the dry salting of food, the use of small quantities of salt, only 2½ percent, gives only a weak brine with but little preservative action, thus necessitating rapid fermentation in order that acid will quickly develop to act as the preservative. In dry salting with large quantities of salt, 15 to 20 percent, as is common for salting meats and fish, the salt brine is the main preservative. With wet brining, the vegetables must be covered with the brine in order to exclude air. Weak brines are used in making dill pickles, fermented peppers, and green tomatoes. With these, the acid produced in fermentation exerts a favorable action and gives a desirable product. With onions and cauliflower, fermentation produces an undesirable product, so that high salt brines are required and the resultant product is then freshened in water.

These same principles of preservation were also stressed as a result of experimental work at the Michigan and North Carolina stations, the latter in cooperation with the Department.

Practical suggestions on brining.—The Michigan station pointed out that in a season when green tomatoes are especially abundant there frequently is a dearth of cucumbers for pickling, because a hard, early frost that kills cucumber and tomato vines will ruin cucumbers but leave large quantities of the less sensitive green tomatoes in good condition. Under these circumstances, the station suggested that the

green tomatoes be used in place of cucumbers either dilled whole or made into sweet sliced pickles, pickle relish, or canned brined pickles.

Work at the North Carolina station (in cooperation with the U. S. Department of Agriculture) showed that many vegetables might be preserved merely by covering with brine of a suitable salt content. Unshelled peas and lima beans and uncut green beans covered with a 15 percent brine (kept up to this concentration by addition of sufficient salt) and held in open unsheltered containers for as long as 12 months remained in excellent condition, as judged by color, texture, and freedom from spoilage. The station pointed out that this simple procedure may be of value in the emergency preservation of certain vegetables in foreign areas reoccupied by Allied Armies. With better facilities available, such as blanching equipment, cold-storage space, and adequate labor, better products result. Work at the station demonstrated that better products were obtained when blanching was practiced. When the brine-preserved material was used directly, as in soup mixtures, the moisture losses accompanying desalting were reduced and the salt of the product went toward seasoning the soup. Okra, corn, lima beans, and snap beans were successfully used in this way.

Aside from the general procedures presented for the home practice of salting and pickling, the Montana station warned that neither iodized salt nor hard water should be used. In the acid-brine canning method, home-made vinegar should not be used but instead a good quality of vinegar from the grocery store; warning was also given that in using the product it should be boiled 15 minutes before tasting.

ECONOMIC AND SOCIAL ADJUSTMENTS

Efforts to step up agricultural production have been aided materially by the annual estimates of maximum production capacity made by members of the State station staffs working in cooperation with the specialists of the Department. Methods and procedures have been evolved whereby the estimates of possible production have been made quickly, at relatively small expense, and with surprising effectiveness.

Paralleling the production program have been the efforts designed to move products from the farms and ranches of the country to ultimate consumers with the least possible loss of time and materials. Because of overburdened highway and rail facilities, transportation has been a bottleneck in marketing. It was timely, therefore, that marketing and transportation studies should receive emphasis over more normal peacetime research undertakings.

There follows some evidence of the findings of the stations on the economic and social side of agriculture and rural life reported during the year.

HELPING TO MEET LABOR REQUIREMENTS

Labor requirements and shortages.—The amounts of labor required for desired wartime agricultural production and the available supplies of labor were studied by most of the stations. Many of the studies were in cooperation with the War Food Administration, War Manpower Commission, Bureau of Agricultural Economics, State employment departments, State War Boards, and others.

Data were released promptly and used effectively by a number of agencies including the agricultural extension service in administering the farm labor program, State and county war boards, employment services, and Selective Service Boards. They served a variety of purposes such as determining the needs of farmers individually and by areas for labor, locating agricultural labor camps, and supplying information pertinent to the deferment of farm laborers.

A study by the Arizona station showed that the peak load for labor exceeded 40,000 workers, of which approximately 50 percent had to be drawn from sources other than resident laborers and Mexican nationals steadily employed. Another study of 5 counties showed that during the year the requirement for hired labor varied from 20,000 to 50,000 men in addition to 7,600 year-round employees.

An investigation completed by the Maryland station of the hours required for different crops and livestock showed an estimated 38,000 to 41,000 laborers are needed in the State during the winter and 80,000 to 87,000 during the summer.

The Missouri station determined that during the first year of the war the State lost about 25 percent of the farm operators, family workers, and hired labor; 10 to 15 percent of the farms were closed up or consolidated with adjoining farms; and average wages were increased 30 to 38 percent, respectively, for year-round and seasonal labor. Despite these changes farm output was not decreased.

According to North Carolina station investigations, approximately 50,000 men and boys (44 percent) left the farm to enter the armed forces or to work in war industries or nonfarm occupations from December 1, 1941, to May 1, 1942. The movement from agriculture increased during 1942 and 1943. Studies in 1944 showed approximately 75,000 farm people in the armed forces alone and a 10-percent shortage in the regular farm labor forces. There was a rather large amount of unused labor, especially Negroes, in the urban centers and in certain agricultural areas, and it appeared that proper recruiting and a well-planned educational program might adequately meet the labor situation.

The West Virginia station in a study of unemployment and land use in a marginal agricultural area found an appreciable amount of unemployment on small subsistence farms. A significant number of the unemployed, both farm and nonfarm, were willing to move provided a definite and acceptable job was available. Public encouragement of migration appeared to be desirable and necessary.

The Oregon station published information as to the amount and seasonal distribution of labor necessary to attain war production goals by months, localities, enterprises and operations, and opportunities for saving labor for growing and harvesting cane fruits, strawberries, apples, pears, potatoes, hops, beans, and sweet and sour cherries.

Among other studies serving particular war needs are those of the Washington station on labor requirements and seasonal needs for grains, hay, dairy cows, hogs, and beef and feeder cattle; the Mississippi station on labor requirements by months and crops for type-of-farming areas; the Utah station on farm labor needed to meet production goals; and the South Carolina station on labor losses and shortages.

Labor methods and efficiency.—A number of studies of methods of performing operations and use of equipment have helped to increase labor output. For example, the Kentucky station showed that the output per hour of labor could be increased 25 to 70 percent in making hay and setting, pulling, cutting, housing, and stripping tobacco by improvement of methods. By coordinating cutting and housing crews to avoid unnecessary delays, some crews were able to eliminate nearly all lost motion.

Improved methods were developed by the Florida station for tying staked tomatoes, handling celery seedbeds, setting and harvesting celery, and picking snap beans and citrus fruits. The new method of handling celery seedbeds reduces labor requirements about 50 percent.

A survey by the Indiana station as of May 1, 1944, of 88 dairy plants handling about 43 percent of the milk and cream marketed in the State showed the plants were handling 36 percent more milk but slightly less cream than in April 1940 with only 6 percent more labor. Employees were handling 11 percent more milk per capita in 1944 than in 1940. Average hours per week had increased from 49.6 to 53.6, and the percentage of women employed from 14.6 to 17.6.

Use of labor in milking and doing chores on dairy farms was studied by the Vermont and New Hampshire stations. By changing the barn arrangement and work routine and providing suitable and adequate low-cost equipment, the time required for dairy chores for the 22-cow dairy studied by the Vermont station was reduced from 5 hours 44 minutes to 3 hours 39 minutes per day and the distance traveled from 3¼ to 1¼ miles. The better milking methods developed by the New Hampshire station reduced the required hours one-third in some cases and one-half in others.

The labor requirements per bird to produce turkeys were found by the Washington station to be 1.34 man-hours for flocks of 1,230 poults or fewer and 0.78 hour for flocks of 2,750 birds or more.

Analysis of over 6,000 AAA work sheets for 1943 by the Wisconsin station revealed that only one-eighth of the farmers had a regular hired man and but few a strong family labor force. An able-bodied operator and his wife without regular hired help or the help of children over 16 years old cropped 57 acres; with grown sons at home the average was 25 percent higher, and with regular hired help about 50 percent more.

The Michigan station estimated that at least 1,000 farmers in the State saved a total of 50,000 man-hours in 1943 by the construction and use of home-made grain elevators and that 2,000 farmers saved a total of 100,000 man-hours by an adaptation of the buck rake. Both were developed by the station.

A survey by the Maryland station showed that on June 30, 1943, approximately 50 percent of the agricultural machinery in the State was in good or excellent condition, 33 percent in fair condition, and 15 percent in poor condition. The data were used in estimating the number of additional machines needed and possibilities for construction and use of home-made equipment. Nearly 5,700 machines were repaired during the year at 105 repair centers operated by the State Department of Education.

AIDING TRANSPORTATION AND MARKETING

Because of gasoline, rubber, and motortruck limitations, one of the foremost problems of farmers has been the transportation of products to market. Most of the stations cooperated with Federal and State agencies, war boards, and transportation committees in providing facts through research to help alleviate the situation.

The Kentucky station assisted the State Dairy Industry Committee in making three regional transportation surveys and the Regional Livestock Committee at Louisville and Lexington in formulating plans for the conservation of farm-to-market transportation.

The Corn Belt Research Committee, representing the experiment stations in 12 Corn Belt States and Oklahoma and Kentucky, cooperated with the Department in a study of livestock trucking. Only 29 percent of the pick-up trucks, 39 percent of the standard trucks, and 54 percent of the semitrailers and truck trailers were loaded to 100 percent of normal net capacity. Many carried loads of 50 percent or less capacity and did not carry return loads. The study showed that total receipts in 68 public stockyards by trucks decreased from 70 percent in 1941 to 58 percent in 1943 for cattle and from 70 to 67 percent for hogs.

The Missouri station estimated that over 541,000 tons of livestock in the State would be trucked to market during 1944 and nearly 25,436,100 truck-miles would be necessary. Reasonable adherence to rules and suggestions formulated in plans for conserving transportation would decrease the truck-miles by 1,493,000.

In the Knoxville area of Tennessee, the Tennessee station found it would be possible to reduce truck mileage for the collection of milk from farms by 37½ percent. Farmers who delivered their own milk hauled only an average of 2.9 gallons per mile and had an unused truck capacity of 66 percent, whereas route haulers averaged 6.6 gallons and only 11 percent of truck space was not used.

An investigation by the Wisconsin station of farm-to-factory milk hauling aided State and Federal agencies in instituting a program which saved 15 percent of 15,000,000 truck-miles a year. Information on the condition of trucks was used to determine the major repair parts and the number of new trucks needed for replacement purposes.

The method formulated by the Indiana station and put into operation in a large tomato cannery for delivery of tomatoes by appointment spread the deliveries throughout the day to relieve congestion, saved labor and truck time while waiting for unloading of the trucks, and enabled the factory to use its labor more efficiently. With the new system truckers commonly delivered four loads a day instead of three.

A study of the Louisiana station showed that it is feasible to load several kinds of vegetables in one car and ship them directly to smaller markets, thereby saving about 3 days in transit and reducing the loss due to spoilage as much as 8 to 10 percent. Other advantages of the method are the conservation of trucks, tires, and gasoline used in hauling from terminal markets to small towns and the saving of cartage and rehandling costs. Louisiana shippers were cooperating by shipping as many loads of mixed vegetables as was feasible.

Many additional studies by the State stations that have pointed the way to savings in the movement of farm products to market could be

cited; as, for example, those of the Maryland, Indiana, Mississippi, Oklahoma, Missouri, and Louisiana stations on transportation of milk, of the Wisconsin and Maryland stations on truck mileage and age and condition of trucks, and of the Maine station on hauling potatoes.

The Maryland station assisted the Governor's Committee on the Baltimore Wholesale Fruit and Vegetable Markets in preparing plans for improving the wholesale and farmers' market facilities by making studies regarding the owners, occupants, acreages, assessed values and other factors for the areas within the Camden wholesale market and the Marsh farmers' market. Estimated costs were prepared for alternate improvement plans. It was estimated that the cost of acquiring additional land, improving old buildings and constructing new ones, paving streets, etc., would be four and one-half to five million dollars. The improvement plans include the enlargement of the Camden wholesale market and the increase of the area for use by farmers to about three times that used at present and the enlargement or relocation of the Marsh market.

A study of the marketing of dairy products in Portland, Maine, by the Maine station showed that fresh milk was purchased by about 97 percent of the families, cream by 44, canned milk by 66, butter by 96, and margarine by 10 percent. The average per capita consumption was 2.8 quarts of milk per week, one-half pint of cream per month, 2.1 cans of canned milk per month, and 2.3 pounds of butter and margarine per month. In another study the station found that sales of farm butter have dropped from 8.4 million pounds in 1909 to 2.4 million pounds in 1942. This change has been due, in large measure, to an increase in the value of milk received by milk shippers as compared with that of farm butter producers. This difference in prices increased from 1 cent per 100 pounds of milk in 1921–25 to $1.11 during the last half of 1943.

The Maryland station made an extensive study of the relation between retail prices and quality of peas, tomatoes, and yellow and white corn packed within and outside the State and sold in different types of stores. Wide variations were found between the retail prices for the same quality of canned goods in different stores and for the same quality of products within the same store.

Variations in per capita expenditures for apples are due chiefly to economic necessity, according to findings of the New York (Cornell) station. About the same proportion of the food dollar was spent for apples regardless of income. Prices paid were highly related to income, high-income families paying nearly twice as much per pound as low-income families.

Consumers' preferences as to milk distribution methods were determened by the Rhode Island station for the city of Providence, where 92 percent of the milk used is delivered to the door. Very few consumers were willing to change to exclusive store purchases. Decided preference was expressed for the allocation of areas of the city to one or two dealers rather than to discontinuance of home delivery.

Eighty-one percent of the families interviewed in a study by the Ohio station in cooperation with the Junior Women's Club of Coshocton, Ohio, stated that they would be satisfied with alternate day deliveries of milk on retail routes after the war, and 84 percent of the regular purchasers of cream were willing to have one type weight (30 percent butterfat) for cream continued.

The Connecticut (Storrs) station determined that alternate-day retail milk deliveries are satisfactory biologically where home refrigeration facilities are adequate. The system of alternate-day and daily deliveries in use at the time of the study as compared with the former system, was saving the rural towns of Connecticut 1,300,000 miles of travel annually, and the station estimates that the saving could be increased to 2 200,000 miles by the adoption of exclusive territories with alternate-day deliveries.

The Illinois station made available to foresters information obtained from wartime timber-marketing projects for use in marketing, estimating, and scaling timber. Data on lumber grade recoveries were used in formulating log ceiling prices proposed for Illinois and accepted by the Office of Price Administration.

The Nevada station in a study of the market value of wool as affected by shrinkage found that in many cases the price paid for wool purchased on contract before shearing was 15 to 20 cents per pound below the value based on clean wool in the Boston market at the time of delivery.

Investigations by the Florida station of citrus cooperative associations revealed that an association needs to handle about 200,000 boxes of fruit annually to be successful. High prices received for fruit, low packing costs, and large volume of fruit handled were found to be closely related.

COSTS AND PRICES

Information obtained by the stations on costs of producing a variety of crops has provided basic data for the determination of price ceilings and support prices and has been valuable to farmers in planning farm operations. Only a few examples can be cited here.

Based on data obtained from farm-accounting investigations, information on rental rates for farm machinery borrowed from neighboring farmers was formulated and given to the public by the Illinois station. Data on current costs of producing crops and livestock products and on agricultural income from these investigations were useful in connection with the establishment of policies and preparation of reports.

The Nebraska station has secured information from several hundred farmers upon the cost of operating farm equipment. As a result of the equipment shortage the exchange use of farm machinery has been greatly increased.

The cost of producing apples in Illinois in 1943 was determined to be $1.89 per packed bushel. When costs of transportation and storage were added the total cost per bushel at point of distribution was $2.29. The study was made by the Illinois station at the request of the State Horticultural Society and the National Apple Institute, and it furnished a basis for discussions with the OPA relative to price ceilings.

The Washington station reported, from a study of the records of 180 growers, that the average cost of growing, harvesting, packing, and storing apples during the 1943 season increased 36 percent over 1942. Costs per box in 1943 were $1.44 for growing and harvesting, 26 cents for boxes and box making, 37 cents for packing, and 17 cents for storing, or a total cost of $2.33. According to apple growers of the State, presentation of these data resulted in an adjustment of the contemplated ceiling price by more than 50 cents per box.

The Maine station obtained information on the amounts of materials and cost of producing certified seed potatoes in relation to table stock. This information was furnished a committee of Aroostook County producers and dealers of certified seed in Presque Isle relative to the establishment of a ceiling price for certified seed by the Office of Price Administration.

Data on the costs of producing potatoes, sweetpotatoes, soybeans, peanuts, milk, and sugarcane, obtained by the Louisiana station, have been analyzed and furnished to farmers and the OPA for guidance in fixing prices on these products.

According to results of Arizona station studies, the cost of dairy feed in June 1943 was 250 percent of the 1935–39 cost; the labor cost in the dairy industry was 220 percent; and the combined index was 235 percent of the base period 1935–39. The price received for fat in Grade A milk in the Phoenix area during July was only 195 percent, and for fat in churn cream 182 percent.

At the request of the OPA a study of production costs of coffee in Puerto Rico was made by the Puerto Rico University station in cooperation with the Extension Service. This study was necessary in order to fix the price of coffee at a just level and to insure adequate rewards to the producers, while safeguarding the consuming public from an inflationary tendency on this crop.

The dairy department of the Utah station, at the request of the OPA, has made a study on the cost of producing butterfat with cows producing at different levels and with varying costs of feed and labor. These data were used to decide the price paid for milk in the Salt Lake area.

At the request of the OPA and a group of producers, a study of the cost of strawberry production under wartime conditions was made by the Louisiana station. Costs and returns for the strawberry enterprise under 1943 and 1944 conditions were obtained from a group of representative producers, and the data were summarized, with comparisons of costs and returns under pre-war conditions as obtained from a detailed study made in 1938. This information was used by the industry and the OPA in planning ceiling prices for the 1944 strawberry crop in Louisiana and in establishing support prices for cold-pack strawberries.

A study by the Mississippi station showed that the ceiling price of peanuts in 1942 was too low and the two-price system inequitable. A revised program was suggested and incorporated in the 1943 Peanut Production Program. It included a uniform price slightly higher than that prevailing in 1942, centralization of production to facilitate harvesting and marketing, and provisions for adequate seed and harvesting equipment.

The costs per acre of producing truck crops based on normal yields and 1943 cost rates were established for cabbage, cantaloups, cucumbers, lima beans, peas, peppers, squash, snap beans, tomatoes, and watermelons in major producing counties of the State by the North Carolina station. These data have proved particularly useful from the standpoint of estimating labor requirements, the establishment of production goals, and the setting of reasonable price ceilings on these crops by OPA.

Studies by the Virginia station in the Roanoke milkshed of the cost of producing milk in relation to returns yielded information which

when presented before public hearings resulted in price increases to producers, who in turn were enabled to increase milk production needed during the emergency.

The Maryland station completed a study of the trends of prices of farm products, cost of living, and real estate; the similarity of price changes during World Wars I and II; and the influence of price ceilings and price supports. Maryland farm prices have risen 110 percent since 1939, the increase ranging from 63 percent for dairy products to 200 percent to tobacco. Dairy feed has risen 70 percent, and farm wages 89 percent. Real-estate prices have risen 38 percent since the beginning of World War II.

A study of the Louisiana station of sorghum grown for industrial alcohol manufacture showed the cost per acre averaged $3.41 per ton and the gross return $4 per ton, giving a profit of $4 per acre and a return for labor of 35 cents per hour.

A study by the North Carolina station of credit conditions in three counties of the State has revealed that cost of credit to farmers for operating expenses are still high, although it has been reduced in recent years. The most expensive form of short-time credit has been furnished by supply merchants. In 1940 the average charges for time purchases correspond to an interest rate of no less than 33.98 percent per annum. In comparison, the cost of loans from the production credit associations are much cheaper. For the average loan from this source the farmers pay 8.94 percent in Wake County, 6.01 percent in Johnson County, and 10.15 percent in Guilford County.

Bank studies by the Iowa station showed that loans by rural banks have been declining, investments by banks in Government securities increasing rapidly, and the cash resources of the banks increasing, while bank deposits have risen about 60 percent during 2 years. The attention of the public has been called to the danger of inflation represented by the high deposit totals in the banks. The unusually good program of debt payment followed by farmers in recent years has been revealed.

LAND USE AND VALUE STUDIES

On the island of Vieques, off the east coast of Puerto Rico, expropriation for war purposes of some 21,000 acres of land, or nearly two-thirds of the island, has created a difficult economic situation for the people. At the request of the Puerto Rico Legislature, the Puerto Rico University station made a survey of nonrestricted Navy lands to determine how they might be used to solve the problem. As the result of this study, funds were made available for the purchase and operation of Central Playa Grande, for the operation of a processing plant for sugar byproducts, and for the distribution of land formerly held by the Eastern Sugar Associates. The survey showed about 7,800 acres of land on which 400 individually operated farms and a 200-acre demonstration farm could be established and 3,200 acres on which 40 livestock farms could be established. The remaining 1,500 acres would be devoted to forestry and wildlife reservations.

In an appraisal of land utilization in Edgefield County, S. C., the South Carolina station found that the war had led to more extensive cooperation among farmers and had promoted a greater exchange of labor and equipment and more custom work than ever before. In 1943, 525 percent more peanuts were grown in the county than in 1940;

soybeans were increased 125 percent; barley, 2,000 percent; oats, 190 percent; wheat, 61 percent; milk, 39 percent; and eggs, 29 percent.

Records kept by farmers cooperating with the Nebraska station show the types of farm organization most profitable in sections of Nebraska. In south-central Nebraska, for example, the only farmers who secured a fairly satisfactory return from farms with fewer than 80 acres in crops were those who specialized in livestock enterprises, such as dairying and poultry. Farmers who changed from horsepower to tractor power and failed to increase the amount of work accomplished usually received a smaller income than before the change.

In a cooperative study with other States of the north-central region and the Department, the Indiana station has found a steady upward trend of Indiana farm prices. There was an average increase of 44 percent within the 3-year period 1941–44. In the opinion of the station this trend offers a potential threat to a speculative rise in farmland values.

A survey of land values in Story County, made by the Iowa station with the cooperation of real estate brokers, indicated that land values had increased from an average of $100 an acre on November 1, 1942, to $119 per acre on November 1, 1943. A gain of $12 per acre was determined for the previous year. The need for controls if inflationary forces in the land market break loose was indicated.

The Ohio station found that average prices of farm real estate have increased much more rapidly on soils of low productivity than on soils of high productivity. Apparently low-quality land is being overpriced to an alarming degree. Small farms adapted to part-time subsistence farming have advanced in price to a point well beyond the probable future ability of the land to pay for itself out of farm income.

A study of pertinent factors by the Missouri station to be considered in buying farm land should be of material assistance to returning servicemen and defense-plant workers who may wish to buy or return to farms in the State. A sample study area has been set up on each of 11 land-use classes in the State. To be considered are prospective values of land, opportunities of buying land at reasonable prices, maximum amount of debt that might be carried safely, and minimum size of farm needed before the land-value and debt-capacity estimates are significant.

POPULATION STUDIES

Studies by the Wisconsin station show that the majority of country neighborhoods persist and their activeness is related to the percentage of tenants, length of residence of families, and a certain proportion of families with "mixed" nationality background. Rural communities made up of farmers and villagers or small-town people are definitely of greater importance in rural society than 20 years or even 10 years ago, measured in terms of increased contacts in school, church, and social agencies.

The Arkansas station found that the population of Yell County has been exceptionally mobile and responsive to outside employment opportunity. The rate of migration to new settlement areas in the delta of southeastern Arkansas and northeastern Louisiana has been higher than from any other hill county in the State. In Boone County the renter farms more land than the owner-operator, is about 8 years

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younger than the owner, participates more in community organizations, receives somewhat less medical services for a slight excess of illness, has accumulated less in equipment and furnishings of the house, and receives a family income which averages approximately the same as that of the owner.

A study by the South Carolina station showed that at present rates of population increase and employment only 46 percent of the white and 35 percent of the Negro boys on bona fide farms in the State are needed to replace farm workers who die or retire. Thus, it is necessary to expand production if all potential workers are to be fully employed. Limits to agricultural productioun suggest that full employment after the war will depend upon substantial increases in industrial opportunities.

An Oklahoma station study shows that the rural population of 7 southeastern counties decreased 25 percent between April 1, 1940, and January 1, 1944. Whereas in 1940 there were 111 males to each 100 females in the counties studied, in 1944 there were 100 males to 100 females in rural-farm population and only 86 males to 100 females in the rural-nonfarm population of these counties. The growing importance of women in the rural labor force is an inevitable consequence of the changes indicated. The number of males 18 to 37 years of age, inclusive, decreased 64 percent in the rural-nonfarm and 47 percent in the rural-farm populations; and the acreages per farm and acreage in crops increased 34 and 73 percent, respectively. The percentage of full owners increased from 32 to 36 percent and that of part owners from 8 to 20 percent.

According to North Carolina station findings during the decade 1930–40, the farms of the State contributed to the State and Nation 200,000 more people above 10 years of age than they received. This loss by migration is equal to 13.5 percent of the available farm population above 10 years of age. In spite of this heavy loss by migration, the rural-farm population above 10 years of age gained 9.1 percent. Had no migration at all occurred during the decade, the increase would have been 26.1 percent.

ANTICIPATING POST-WAR NEEDS

While the major efforts of both State and Federal research and action agencies thus far have been to produce enough food and fibers and to deliver them wherever needed here at home or abroad, appropriate thought has been given to some of the probable needs of agriculture and rural life in the years following the war, particularly those of the more immediate periods of transition from cessation of hostilities to the advent of more normal peacetime economy. In efforts to foresee post-war problems, the land-grant colleges and universities, through their agricultural experiment stations and extension services, have cooperated for the past 3 years or more with the Department's Interbureau Committee on Post-War Programs or with regional committees on post-war programs, consisting of both State and Federal personnel. More recently, the land-grant college committee on post-war agricultural policy has been organized and actively engaged in the study of post-war problems at the national as well as at regional and local levels. By giving post-war problems the preliminary attention that they deserve before the end of the war actually arrives, the stations, as well as Federal agencies, will be enabled to deal with these problems more

effectively and with less lost motion than otherwise would have been the case.

STATISTICS—PERSONNEL, PUBLICATIONS, INCOME, AND EXPENDITURES

PERSONNEL AND PUBLICATIONS

As shown in table 1, the experiment stations in 1944 had 4,525 total research workers, including 2,226 full-time workers and 2,299 workers who divided time between research and teaching or extension work. As compared with 1943, this was a reduction of 255 total workers and 50 full-time workers. These figures are based on information shown in the publication Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, 1943–44, and represent the personnel situation near the beginning rather than at the close of the fiscal year. They do not include temporary employees, such as assistants and fellows, nor staff members who were on leave of absence for service with the armed forces.

In 1944, the stations published 933 bulletins, circulars, and reports, 1,753 articles in scientific journals, and 560 miscellaneous publications. The comparable figures in 1943 were 1,130, 2,137, and 740. Special articles and reports issued by the stations in processed form are not included in these figures.

INCOME

The 1944 income of the experiment stations from all sources was $26,942,662.04, as compared with $24,203,873.56 in 1943. The total of available Federal-grant funds was $7,001,207.08 and that of non-Federal funds $19,941,454.96, or $1 of Federal funds to approximately $2.85 of non-Federal funds.

Federal-grant funds.—The total of funds available to the States, Alaska, Hawaii, and Puerto Rico for the fiscal year 1944 was $7,001,207.08. Each State, Hawaii, and Puerto Rico received $90,000 under the Hatch, Adams, and Purnell Acts, while Alaska received $37,500. The total appropriated under the foregoing acts was $4,537,500. The appropriation under title I of the Bankhead-Jones Act was $2,463,707.08. This was allotted to the States, Alaska, Hawaii, and Puerto Rico on the basis of their rural population, and $63,707.08 of this amount was made available to prevent any reductions due to changes in population as shown by the 1940 census.

Non-Federal funds.—The funds available for research by the experiment stations from non-Federal sources totaled $19,941,454.96 in 1944, as compared with $17,277,666.48 in 1943, an increase of $2,663,788.48. These non-Federal funds included funds appropriated by the States, research grants, fellowship funds, and receipts from fees, sales, and miscellaneous sources.

The 1944 income from the various funds is shown for the States, Alaska, Hawaii, and Puerto Rico in table 2, and the totals of disbursements of Federal-grant funds through 1944 are shown in table 8.

EXPENDITURES

Classified expenditures are shown under the Hatch Act in table 3, the Adams Act in table 4, the Purnell Act in table 5, and the Bankhead-Jones Act in table 6. Non-Federal fund expenditures are shown in table 7.

TABLE 1.—*Organization, personnel, and publications of the experiment stations for the year ended June 30, 1944*

Station	Date of legislative assent to Hatch Act	Date of organization under Hatch Act	Personnel					Publications					
			Full-time research	Research and teaching	Research and extension	Research, teaching and extension	Total research workers	Station publications		Articles in scientific journals		Miscellaneous publications	
			Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Pages*	*Number*	*Pages*	*Number*	*Pages*
Alabama	Feb. 27, 1889	Apr. 1, 1888	35	25	1	1	62	2	21				
Alaska	Mar 2, 1929	May 1, 1931	4	1	1		6	5	57				
Arizona	Mar. 19, 1889	July 1, 1889	25	33			58	17	418	14	83	5	12
Arkansas	May 7, 1889	Apr. 2, 1888	18	34	2		54	10	460	17	90		
California	Mar. 12, 1889	Mar. 13, 1888	85	189			274	21	1,029	291	1,943	156	1,811
Colorado	Mar. 25, 1889	Feb. 20, 1888	27	41	1	3	72	23	376	17	136	15	50
Connecticut:													
State	May 18, 1887	May 18, 1887	21	10		3	34	10	447	26	121	14	24
Storrs	do	Apr. 1, 1888	55				55	4	161	12	125	1	16
Delaware	Apr. 14, 1887	Feb. 21, 1888	9	13	2	3	27	9	181	9	64	8	34
Florida	June 7, 1887	Mar. 16, 1888	86	12	4	3	105	25	575	62	264	70	110
Georgia	Dec. 24, 1888	Feb. 18, 1888	38				38	14	422	18	147		
Hawaii	Mar. 31, 1911	July 1, 1929	22	10			32	4	188	2	4	10	30
Idaho	Jan. 23, 1891	Feb. 26, 1892	13	28	3	6	50	27	272	16	100		
Illinois	May 11, 1887	Mar. 21, 1888	55	85	2	6	148	6	237	2	11		
Indiana	Jan. 19, 1889	July 1, 1887	106	34	2	3	145	32	1,035				
Iowa	Mar. 1, 1888	Feb. 17, 1888	88	125	29	9	251	25	1,193	69	778		
Kansas	Mar. 3, 1887	Feb. 8, 1888	38	96			134	23	783	140	280		
Kentucky	Feb. 20, 1888	Apr. 29, 1888	68	21		6	95	19	614	34	152		
Louisiana	July 12, 1888	Apr. 5, 1887	55	31		1	87	30	962				
Maine	Mar. 16, 1887	Feb. 16, 1888	33	12		1	46	11	597	9	60	9	402
Maryland	Mar. 6, 1888	Mar. 9, 1888	14	25	6	20	65	7	220	27	54	12	24
Massachusetts	Apr. 20, 1887	Mar. 2, 1888	61	18			79	16	647	43	244		
Michigan	Apr. 12, 1889	Feb. 26, 1888	55	85	7	6	153	26	1,039	42	307		
Minnesota	Feb. 4, 1889	Jan. 26, 1888	43	108	1	3	155	10	233				
Mississippi	Jan. 31, 1888	Spring 1888	31	20		2	53	48	857	13	80	87	99
Missouri	June 11, 1889	Jan. 31, 1888	9	71	1	2	83	43	1,129	46	92		
Montana	Feb. 16, 1893	July 1, 1893	27	19	1	10	57	20	440	13	54	3	41
Nebraska	Mar. 31 1887	June 14, 1887	33	27	2		62	22	552	21	42		
Nevada	Feb. 8, 1889	December1887	15	1			16	6	149				
New Hampshire	Aug. 4, 1887	Feb. 22, 1888	10	39		7	56	9	416	5	15		

New Jersey:													
College	Mar. 16, 1887	Mar. 5, 1888	48	61	4	3	116	38	720	73	146	11	44
State													
New Mexico	Feb. 28, 1889	Nov. 14, 1889	10	17	1	1	29	8	211	2	5	2	2
New York:													
Cornell	Mar. 30, 1887	Apr. 30, 1888	25	149	4	18	196	22	1,157	387	2,790		
State	(1)		74				74	24	346	4	76	6	10
North Carolina	Mar. 7, 1887	Dec. 5, 1889	65	41	3	7	116	19	615	34	231	20	200
North Dakota	Mar. 8, 1890	Oct. 15, 1890	29	21		2	52	11	192				
Ohio	Mar. 16, 1887	Apr. 2, 1888	121				121	12	358				
Oklahoma	Oct. 27, 1890	Aug. 14, 1891	22	57	1		80	25	679	69	409		
Oregon	Feb. 25, 1889	July 2, 1888	60	44		6	110	55	685	17	85		
Pennsylvania	June 3, 1887	June 30, 1887		138			138	21	487	49	346	16	268
Puerto Rico	Aug. 16, 1933	Nov. 14, 1935	46				46	11	303				
Rhode Island	Mar. 31, 1887	Nov. 3, 1881	18	8		5	31	14	383	9	49		
South Carolina	Dec. 22, 1887	January 1888	50	22		1	73	7	326	10	61		
South Dakota	Mar. 11, 1887	Nov. 17,1887	19	20		1	40	14	280	12	54		
Tennessee	Mar. 29, 1887	July 24, 1887	58	15		2	75	9	259	6	84	14	637
Texas	Apr. 2, 1887	Jan. 25, 1888	149	2			151	18	569	28	150	84	262
Utah	Mar. 8, 1888	Nov. 16, 1889	19	38	1	6	64	6	205	10	165	4	48
Vermont	November 1888	Feb. 28, 1888	20	7	5	4	36	28	761				
Virginia	Feb. 29, 1888	June 13, 1888	45	10	2	5	62	21	516	25	159		
Washington	Mar. 9, 1891	May 1, 1891	78	31			109	19	647	47	356		
West Virginia	Feb. 22, 1889	June 11, 1888	21	32		7	60	12	291	21	185	1	11
Wisconsin	Session of 1887	July 1, 1887	57	74	5	17	153	6	244				
Wyoming	Jan. 10, 1891	Mar. 27, 1891	13	28			41	9	264	2	14	12	28
Total			2,226	2,028	91	180	4,525	933	26,208	1,753	10,611	560	4,163

[1] First made eligible to receive part of the State allotment of Federal funds by legislative act approved May 12, 1894.

TABLE 2.—*Income of the experiment stations for the year ended June 30, 1944*

Station	Federal grants [1]			Non-Federal							Grand total
	Hatch, Adams, and Purnell [2]	Bankhead-Jones	Total	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Balance from previous year	Total	
Alabama	$90,000	$82,695.12	$172,695.12	$260,070.00	$10,639.60		$186,929.55	$5,212.50	$385,808.42	$848,660.07	$1,021,355.10
Alaska	37,500	2,252.44	39,752.44	7,500.00			28,254.54		5,100.90	40,855.44	80,607.88
Arizona	90,000	13,285.16	103,285.16	106,920.78			37,615.84		9,537.07	154,073.69	257,358.85
Arkansas	90,000	63,983.20	153,983.20	159,740.59			53,250.13	947.30	26,418.00	240,356.02	394,339.22
California	90,000	81,893.64	171,893.64	1,243,646.86	91,532.10		26,698.37		121,827.66	1,483,704.99	1,655,598.63
Colorado	90,000	22,430.96	112,430.96	107,317.38	9,152.34	$621.20	136,501.14		40,673.56	294,265.62	406,696.58
Connecticut:											
State	45,000	11,253.66	56,253.66	137,788.39	13,051.89					150,840.28	207,093.94
Storrs	45,000	11,253.66	56,253.66	56,120.54	16,370.67					72,491.21	128,744.87
Delaware	90,000	5,189.96	95,189.96	48,801.05	12,534.13		70,332.36		10,548.87	142,216.41	237,406.37
Florida	90,000	34,782.16	124,782.16	560,760.92			142,486.11		164,650.50	867,897.53	992,679.69
Georgia	90,000	87,522.92	177,522.92	47,256.31	30,336.75		65,279.42		29,178.64	172,051.12	349,574.04
Hawaii	90,000	9,186.40	99,186.40	113,026.72	1,500.00		36,808.71		1,480.52	152,815.95	252,002.35
Idaho	90,000	14,219.84	104,219.84	30,648.89			65,620.50		4,910.94	101,180.33	205,400.17
Illinois	90,000	86,736.52	176,736.52	442,970.52	31,273.25		145,396.40			619,640.17	796,376.69
Indiana	90,000	62,900.44	152,900.44	359,277.50	76,347.43	19,667.78	292,061.46	8,095.05	227,153.82	982,603.04	1,135,503.48
Iowa	90,000	64,854.64	154,854.64	309,352.59	106,541.26		135,332.83		80,442.49	631,669.17	786,523.81
Kansas	90,000	50,050.96	140,050.96	138,750.00		178,702.46		2,860.00	74,273.18	394,585.64	534,636.60
Kentucky	90,000	81,533.32	171,533.32	99,500.00		279,346.15	75,958.61		122,088.31	576,893.07	748,426.39
Louisiana	90,000	56,502.80	146,502.80	306,086.47	24,584.84					330,671.31	477,174.11
Maine	90,000	20,692.16	110,692.16	88,393.31	2,805.71		49,684.09	20,157.45	10,877.74	171,918.30	282,610.46
Maryland	90,000	30,259.72	120,259.72	115,887.33	7,221.30		68,991.40		35,293.67	227,393.70	347,653.42
Massachusetts	90,000	18,674.92	108,674.92	156,505.48	22,539.18				13,972.69	193,017.35	301,692.27
Michigan	90,000	73,566.60	163,566.60	245,128.63			37,145.34			282,273.97	445,840.57
Minnesota	90,000	57,269.04	147,269.04	316,082.43	78,770.27	4,417.79	92,575.56			491,846.05	639,115.09
Mississippi	90,000	72,651.40	162,651.40	127,500.00	24,524.07		115,903.71	16,934.98	134,668.90	419,531.66	582,183.06
Missouri	90,000	76,967.80	166,967.80	86,212.15	27,707.30	38,935.42	50,075.80		70,090.51	273,021.18	439,988.98
Montana	90,000	15,503.16	105,503.16	93,517.85			126,255.51		52,676.50	272,449.86	377,953.02
Nebraska	90,000	38,776.60	128,776.60	103,303.85			149,874.19			253,178.04	381,954.64
Nevada	90,000	2,734.64	92,734.64				10,442.79		11,204.98	21,647.77	114,382.41
New Hampshire	90,000	8,507.40	98,507.40	8,507.40			8,260.21		15,868.87	32,636.48	131,143.88
New Jersey	90,000	31,260.32	121,260.32	456,350.00	135,191.59					591,541.59	712,801.91

New Mexico	90,000	14,516.00	104,516.00	18,016.00			36,303.35		61,112.85	115,432.20	219,948.20
New York:											
Cornell	81,000	85,030.40	166,030.40	867,244.37				2,041.60		869,285.97	1,035,316.37
State	9,000	9,447.84	18,447.84	389,306.10			6,821.54			396,127.64	414,575.48
North Carolina	90,000	106,085.56	196,085.56	175,630.62			40,891.31	17,079.74	15,581.95	249,183.62	445,269.18
North Dakota	90,000	24,675.76	114,675.76	85,484.71	2,531.03		46,341.83	6.47	16,850.18	151,214.22	265,889.98
Ohio	90,000	93,717.64	183,717.64	612,127.26			205,949.06	35,655.48	812,959.60	1,666,691.40	1,850,409.04
Oklahoma	90,000	68,450.84	158,450.84	231,386.30	800.00	31,500.00	98,788.44	4,417.43	64,537.49	431,429.66	589,880.50
Oregon	90,000	22,790.32	112,790.32	238,558.94	13,146.30	90,150.97	78,160.18			420,016.39	532,806.71
Pennsylvania	90,000	135,322.64	225,322.64	253,067.59	29,512.25		36,400.81		16,458.35	335,439.00	560,761.64
Puerto Rico	90,000	53,213.24	143,213.24	205,169.48			11,330.01			216,499.49	359,712.73
Rhode Island	90,000	2,449.04	92,449.04	3,500.00			15,518.59		6,224.59	25,243.18	117,692.22
South Carolina	90,000	59,464.96	149,464.96	165,000.00			270,108.20		52,085.90	487,194.10	636,659.06
South Dakota	90,000	24,432.44	114,432.44	50,333.00	4,007.91		40,572.03		38,083.40	132,996.34	247,428.78
Tennessee	90,000	77,136.04	167,136.04	85,374.71			95,104.80			180,479.51	347,615.55
Texas	90,000	149,364.76	239,364.76	408,903.00	17,527.20		410,478.77	47,197.72	247,867.39	1,131,974.08	1,371,338.84
Utah	90,000	10,503.68	100,503.68	88,747.00	1,800.00		23,714.27		8,900.44	123,161.71	223,665.39
Vermont	90,000	10,471.60	100,471.60	8,000.00		10,618.19	5,027.16	4,500.00	2,824.47	30,969.82	131,441.42
Virginia	90,000	71,144.56	161,144.56	126,320.00			29,357.59	429.95	5,732.37	161,839.91	322,984.47
Washington	90,000	33,254.64	123,254.64	250,660.46	11,329.69		92,159.25			354,149.40	477,404.04
West Virginia	90,000	55,859.16	145,859.16	74,600.00			68,694.99		33,269.18	176,564.17	322,423.33
Wisconsin	90,000	60,224.88	150,224.88	384,563.00	174,816.00		107,311.00			666,690.00	816,914.88
Wyoming	90,000	6,759.52	96,759.52	37,994.00			61,079.21		31,872.93	130,946.14	227,705.66
Total	4,537,500	2,463,707.08	7,001,207.08	11,092,910.48	978,094.06	653,959.96	3,987,846.96	165,535.67	3,063,107.83	19,941,454.96	26,942,662.04

[1] Includes unexpended balances from the previous year as follows:

Hatch—Connecticut Storrs, $649.46; Delaware, $124.59; Illinois, $929.55; Puerto Rico, $123.92; Rhode Island, $148.19; Vermont, $927.86; Washington, $0.22.

Adams—Alabama, $560.79; Delaware, $920.16; Hawaii, $1,811.56; Illinois, $2.68; New York Cornell, $167.81; North Dakota, 15.98; Ohio, $3,493.34; Puerto Rico, $337.05; Rhode Island, $77.54; Vermont, $3,837.40.

Purnell—Alabama, $96.81; Arkansas, $451.74; Connecticut State, $598.37; Connecticut Storrs, $1,323.15; Delaware, $2,959.36; Illinois, $3,678.45; Massachusetts, $640.83; Michigan, $803.41; New York Cornell, $541.43; Ohio, $7,106.42; Puerto Rico, $946.76; Rhode Island, $788.44; Vermont, $1,201.44; Virginia, $19.41.

Bankhead-Jones—Connecticut Storrs, $991.46; Delaware, $58.62; Illinois, $5,021.03; Missouri, $592.68; New York Cornell, $97.01; Ohio, $2,093.95; Puerto Rico, $2,436.51; Vermont, $1,090.26; Virginia, $7,101,87.

[2] Hatch, $15,000 for each State, Alaska, Hawaii, and Puerto Rico.

Adams, $15,000 for each State, Hawaii, and Puerto Rico; $7,500 for Alaska.

Purnell, $60,000 for each State, Hawaii, and Puerto Rico; $15,000 for Alaska.

TABLE 3.—*Expenditures and appropriations under the Hatch Act (Mar. 2, 1887)*[1] *for the year ended June 30, 1944*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$13,609.27	$80.60		$115.56	$105.69	$159.20	$41.65	$452.07	$435.96			$15,000.00		$15,000
Alaska	10,092.38	911.21	$218.16	39.02	48.63	267.00	211.91	1,481.88	1,543.43	$186.38		15,000.00		15,000
Arizona	14,512.12			1.75		3.35		36.15	446.63			15,000.00		15,000
Arkansas	9,976.27	379.67	1.17	113.52	14.00	1,700.86	59.18	1,950.70	588.07		$216.56	15,000.00		15,000
California	15,000.00											15,000.00		15,000
Colorado	14,204.99	268.70		24.29	4.10	169.90		79.77			248.25	15,000.00		15,000
Connecticut:														
State	7,500.00											7,500.00		7,500
Storrs	3,000.00	395.57	18.90	26.10		139.65	143.44	1,654.32	1,292.63			6,670.61	$829.39	7,500
Delaware	10,715.12	464.71	24.80	855.12	30.24	1,080.33	168.82	529.19	1,131.67			15,000.00		15,000
Florida	14,936.12			35.31				28.57				15,000.00		15,000
Georgia	12,068.42	302.35		1.08		430.04	24.18	1,307.54	866.39			15,000.00		15,000
Hawaii	14,812.96							185.04	2.00			15,000.00		15,000
Idaho	10,659.70	1,085.17	34.48	130.13		797.45	173.25	1,606.97	512.85			15,000.00		15,000
Illinois	11,845.43										344.45	12,189.88	2,810.12	15,000
Indiana	15,000.00											15,000.00		15,000
Iowa	15,000.00											15,000.00		15,000
Kansas	14,079.66	443.82		51.98	9.50	3.96	137.30	96.49	124.82	52.47		15,000.00		15,000
Kentucky	14,517.56	154.62	2.01			325.81						15,000.00		15,000
Louisiana	13,138.33	699.59	7.60	31.86		437.43	210.63	376.85	97.71			15,000.00		15,000
Maine	11,153.10	1,049.78	64.94	311.46	782.64	385.25	281.12	692.57	279.14			15,000.00		15,000
Maryland	11,735.41	245.72	3.62	10.30			2.30	1,860.08	1,142.57			15,000.00		15,000
Massachusetts	13,010.55	319.65				1,562.56		107.24				15,000.00		15,000
Michigan	15,000.00											15,000.00		15,000
Minnesota	11,554.06		1.22				182.10	992.12	1,926.33		344.17	15,000.00		15,000
Mississippi	11,399.66	690.76	19.82	288.81	153.56	934.04	275.94	455.25	282.16	500.00		15,000.00		15,000
Missouri	14,598.73										401.27	15,000.00		15,000
Montana	10,380.14	422.19	16.57	424.70	699.41	2,095.58	188.00	740.86	32.55			15,000.00		15,000
Nebraska	15,000.00											15,000.00		15,000
Nevada	12,110.25	3.30	.35	319.97	81.38	325.25	57.50	1,392.70	529.30		180.00	15,000.00		15,000

New Hampshire	9,259.63	706.30	364.34	457.95	700.00	325.47	345.37	1,159.45	1,681.49			15,000.00		15,000
New Jersey	12,703.21	204.98		4.25	24.00	1,495.32	121.52	379.25	67.47			15,000.00		15,000
New Mexico	12,830.89	268.97	1.93	1.32	511.92	597.53	40.35	365.36	323.30	58.43		15,000.00		15,000
New York:														
Cornell	10,157.29	4.72					500.22	1,510.12	716.01	587.44		13,475.80	24.20	13,500
State	1,336.95							6.70	156.35			1,500.00		1,500
North Carolina	12,680.00	1,064.85	8.64	140.46		733.89	18.83	32.78	320.55			15,000.00		15,000
North Dakota	13,225.32	45.00	6.95	59.06		881.62	15.48	429.40	337.17			15,000.00		15,000
Ohio	10,981.66	505.93	61.55					3,450.86				15,000.00		15,000
Oklahoma	5,902.05	1,457.02	65.73	7.77		466.30	662.41	4,189.14	2,212.36	37.22		15,000.00		15,000
Oregon	11,714.85	809.58		6.11	360.48	151.01	111.01	1,283.87	572.09			15,000.00		15,000
Pennsylvania	10,643.26	248.99	.75			3,678.57		428.43				15,000.00		15,000
Puerto Rico	12,347.79	460.01		192.28			5.00	1,539.42	455.50			15,000.00		15,000
Rhode Island	8,801.81	438.78	11.24	279.93	257.32	707.84	513.55	2,892.01	1,068.51	16.00		14,986.99	13.01	15,000
South Carolina	11,253.76	152.03	.67	227.26	81.60	1,110.11	130.65	1,510.71	453.24		79.97	15,000.00		15,000
South Dakota	11,781.00	548.40	5.63	159.25	29.00	1,507.67	81.37	761.84	125.84			15,000.00		15,000
Tennessee	12,029.78	59.92	126.28	430.56	26.69	764.56	137.93	1,173.05	247.90	3.33		15,000.00		15,000
Texas	12,900.33	892.09		2.49		41.43	40.45	671.61	451.60			15,000.00		15,000
Utah	13,385.32	14.18	26.27	5.50		19.75	124.52	1,297.85	126.61			15,000.00		15,000
Vermont	8,204.22	287.97	10.36	522.82	2,801.24	2,116.25	112.40	142.45	61.45	669.02	71.82	15,000.00		15,000
Virginia	13,740.14	70.40		47.72	12.90		102.85	963.42	62.57			15,000.00		15,000
Washington	13,612.04	562.15		31.31		198.27	38.05	247.68	16.50		294.00	15,000.00		15,000
West Virginia	12,999.96	142.78	5.15		1.00	20.65	283.96	1,349.50	197.00			15,000.00		15,000
Wisconsin	12,869.81	161.91			5.00	130.98	35.93	1,796.37				15,000.00		15,000
Wyoming	12,656.50	569.50	24.57	11.16	35.68	495.52	186.96	951.12	68.99			15,000.00		15,000
Total	628,627.80	17,584.87	1,133.70	5,368.16	6,775.98	26,260.40	5,766.13	44,558.75	20,956.71	2,110.29	2,180.49	761,323.28	3,676.72	765,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 4.—*Expenditures and appropriations under the Adams Act (Mar. 16, 1906)* [1] *for the year ended June 30, 1944*

Station	Expenditures											Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$10,058.27	$107.00	$57.71		$671.30	$516.71	$1,419.69	$767.02	$310.00		$13,907.70	$1,092.30	$15,000
Alaska	6,269.72		262.10				968.18				7,500.00		7,500
Arizona	12,267.21	1,641.75	11.69	$33.25		428.75	538.32	79.03			15,000.00		15,000
Arkansas	12,592.10	114.55		29.49	158.60	50.99	1,388.34	125.98		$539.95	15,000.00		15,000
California	15,000.00										15,000.00		15,000
Colorado	12,791.46	248.71	3.37	23.26	203.77	136.59	1,152.68	108.33		331.83	15,000.00		15,000
Connecticut:													
State	7,500.00										7,500.00		7,500
Storrs	7,500.00										7,500.00		7,500
Delaware	11,223.98	1,049.60	12.05	.25	432.34	194.60	636.78	197.62			13,747.22	1,252.78	15,000
Florida	15,000.00										15,000.00		15,000
Georgia	11,213.40		.52	.83		21.75	3,763.50				15,000.00		15,000
Hawaii	12,695.76		21.44			91.10	1,031.76	380.87			14,220.93	779.07	15,000
Idaho	11,388.98	365.23	20.35	6.67	22.81	711.76	1,195.25	1,082.41	$206.54		15,000.00		15,000
Illinois	14,412.99									416.99	14,829.98	170.02	15,000
Indiana	14,174.00	57.20			20.00	100.00	214.34	434.46			15,000.00		15,000
Iowa	15,000.00										15,000.00		15,000
Kansas	13,791.16		1.00				1,207.84				15,000.00		15,000
Kentucky	14,007.84		22.60				931.33	38.23			15,000.00		15,000
Louisiana	13,173.61	307.69	8.14	4.97		21.32	1,040.25	444.02			15,000.00		15,000
Maine	13,534.93	151.62	20.82			45.23	958.65	288.75			15,000.00		15,000
Maryland	12,003.68		45.93	6.16		18.25	2,501.77	358.56	65.65		15,000.00		15,000
Massachusetts	15,000.00										15,000.00		15,000
Michigan	15,000.00										15,000.00		15,000
Minnesota	14,616.97									383.03	15,000.00		15,000
Mississippi	12,465.35	357.81	41.42	14.45	274.50	474.61	1,170.14	201.72			15,000.00		15,000
Missouri	9,633.99	3.50	215.69		21.00	15.39	4,760.94	39.47	160.00	150.02	15,000.00		15,000
Montana	13,580.50	258.88	25.81	3.90		10.87	722.53	397.51			15,000.00		15,000
Nebraska	15,000.00										15,000.00		15,000
Nevada	12,745.93	375.13	93.21	75.22	12.50	54.72	1,283.69	236.10		123.50	15,000.00		15,000
New Hampshire	14,232.99	143.10	47.76	7.60		49.29	376.65	142.61			15,000.00		15,000
New Jersey	13,823.92	35.25				20.85	942.98	162.50	14.50		15,000.00		15,000

New Mexico	12,521.94	119.35	108.51	20.78	286.63	89.10	1,507.08	305.67	40.94		15,000.00	15,000
New York:												
Cornell	12,302.17					134.08	755.17	260.86			13,452.28	47.72	13,500
State	1,500.00										1,500.00		1,500
North Carolina	13,078.83	449.05	20.57	5.38		304.86	912.01	229.30			15,000.00		15,000
North Dakota	13,504.47	17.27	7.04	4.06		6.00	510.70	950.46			15,000.00		15,000
Ohio	13,483.51	15.31	5.54				1,314.09	181.55			15,000.00		15,000
Oklahoma	11,349.92	40.32	9.48			93.45	2,651.34	855.49			15,000.00		15,000
Oregon	13,006.69	443.77	9.99	27.08	96.32	21.72	912.17	482.26			15,000.00		15,000
Pennsylvania	15,000.00										15,000.00		15,000
Puerto Rico	13,566.50	50.61	11.13		16.20	195.38	1,079.44	33.25			14,952.51	47.49	15,000
Rhode Island	14,240.72	91.55	6.75			8.00	502.33	136.92			14,986.27	13.73	15,000
South Carolina	12,457.63	217.82	5.20	79.55	73.85	33.15	960.55	354.94	694.50	122.81	15,000.00		15,000
South Dakota	12,452.37	60.96	103.92	66.43	201.00	41.63	1,177.93	895.76			15,000.00		15,000
Tennessee	12,744.50		21.26	6.00	14.98	114.31	1,776.84	322.11			15,000.00		15,000
Texas	15,000.00										15,000.00		15,000
Utah	12,926.39	663.84	28.30			61.50	961.42	358.55			15,000.00		15,000
Vermont	13,484.66		21.92			298.52	548.26	459.30	62.36	124.98	15,000.00		15,000
Virginia	13,400.17	313.60		.25	52.03	96.98	925.84	211.13			15,000.00		15,000
Washington	12,688.70	893.29		6.69		7.59	789.44	237.79		376.50	15,000.00		15,000
West Virginia	12,100.00	54.20	7.71			56.43	1,323.87	1,457.79			15,000.00		15,000
Wisconsin	14,469.89						530.11				15,000.00		15,000
Wyoming	13,319.68	291.55	10.47	19.30		47.79	1,284.94	26.27			15,000.00		15,000
Total	670,297.48	8,939.51	1,289.40	441.57	2,557.83	4,573.27	48,629.14	13,244.59	1,554.49	2,569.61	754,096.89	3,403.11	757,500

[1] Extended to Hawaii by act of May 16, 1928; to Puerto Rico by act of Mar. 4, 1931; and to Alaska by act of June 30, 1936.

TABLE 5.—*Expenditures and appropriations under the Purnell Act (Feb. 24, 1925)[1] for the year ended June 30, 1944*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractural services	Supplies and materials	Equipment	Lands and structures (contractural)	Contributions to retirement	Total expenditures		
Alabama	$48,628.23	$1,017.24	$192.13	$135.15	$1,964.45	$63.26	$917.91	$4,967.90	$1,703.73	$410.00		$60,000.00		$60,000
Alaska	12,249.52	231.76	660.76	9.00				1,702.81	146.15			15,000.00		15,000
Arizona	47,388.33	2,175.13	162.39	101.15	306.60	1,099.80	626.36	6,702.24	1,438.00			60,000.00		60,000
Arkansas	46,254.97	702.62	136.38	64.91	1,068.78	95.34	529.66	4,368.52	5,232.11		$771.21	59,224.50	$775.50	60,000
California	60,000.00											60,000.00		60,000
Colorado	49,496.81	1,888.90	122.02	111.74	980.26	125.55	694.13	3,358.64	2,173.30	62.35	986.30	60,000.00		60,000
Connecticut:														
State	27,574.99	33.50	1.35			36.55	283.33	1,270.46	797.07	2.75		30,000.00		30,000
Storrs	21,481.61	166.03	25.30	14.50		30.00	123.83	4,023.43	2,199.35			28,064.05	1,935.95	30,000
Delaware	42,966.76	2,997.35	144.38	7.63	726.62	484.73	608.42	7,154.91	1,782.56	3,126.64		60,000.00		60,000
Florida	53,701.71	1,624.90	12.58	5.30	388.97		163.71	2,606.15	1,496.68			60,000.00		60,000
Georgia	39,176.67	870.09	93.44	7.25	20.00	463.11	766.33	15,604.68	2,998.43			60,000.00		60,000
Hawaii	44,536.15	476.20	13.75				1,753.32	2,795.97	4,040.53	5,445.49		59,061.41	938.59	60,000
Idaho	47,471.47	1,943.80	152.83	86.21	187.50	198.05	586.12	7,768.99	1,465.46	139.57		60,000.00		60,000
Illinois	48,027.72	1,911.29	12.82	40.04		906.55	1,241.85	2,551.04	709.95	1,900.00	758.95	58,060.21	1,939.79	60,000
Indiana	49,052.70	825.85	112.30	111.64		18.50	1,669.59	2,193.22	2,023.46			56,007.26	3,992.74	60,000
Iowa	59,940.00								60.00			60,000.00		60,000
Kansas	57,062.43	300.14	1.00	.15	9.00	86.05	185.43	1,524.76	831.04			60,000.00		60,000
Kentucky	54,045.07	2,105.35	23.82	123.33	41.80	1,732.70	215.86	1,288.65	423.42			60,000.00		60,000
Louisiana	50,537.48	2,409.99	209.86	58.41		16.26	520.74	5,527.94	719.32			60,000.00		60,000
Maine	47,185.15	1,206.58	65.55	42.00	1,103.20	1,305.25	1,156.63	5,977.00	1,958.64			60,000.00		60,000
Maryland	46,041.15	2,027.95	67.70	20.22	20.00	794.06	588.25	6,984.89	2,712.96	39.80		59,296.98	703.02	60,000
Massachusetts	48,233.74	841.02				29.40	124.04	9,106.76				58,334.96	1,665.04	60,000
Michigan	49,361.17	809.79	21.27	.93	120.00	2,373.29	465.33	4,189.88	1,854.93			59,196.59	803.41	60,000
Minnesota	53,786.54	463.52	234.38	82.29	32.93	24.25	616.80	3,392.44	479.64		887.21	60,000.00		60,000
Mississippi	42,736.16	1,345.22	648.56	477.85	757.10	483.98	1,042.97	8,221.31	3,635.37	651.48		60,000.00		60,000
Missouri	38,496.10	956.61	429.42	127.32	148.44	1,032.12	562.49	13,776.28	3,797.45	321.37	352.40	60,000.00		60,000
Montana	47,496.57	931.78	20.35	74.74	1,925.20	337.73	477.69	4,893.66	345.88	3,496.40		60,000.00		60,000
Nebraska	51,534.45	994.48	23.30	128.05	10.00	774.44	318.13	4,972.85	1,244.30			60,000.00		60,000
Nevada	44,894.54	1,578.39	111.61	637.31	946.77	833.48	793.79	7,035.04	2,377.07	332.00	460.00	60,000.00		60,000

New Hampshire	50,614.98	1,060.06	78.47	38.25	364.38	305.72	1,127.66	5,309.03	968.89	132.56		60,000.00		60,000
New Jersey	53,872.66	1,231.78	11.80	24.13	73.00	82.66	523.03	3,095.94	985.00	100.00		60,000.00		60,000
New Mexico	49,747.41	1,556.97	149.81	87.15	1,625.54	888.75	417.31	4,798.76	660.46	67.84		60,000.00		60,000
New York:														
Cornell	44,513.47	1,065.09	7.93	278.72	1,565.00	577.70	1,234.88	1,910.95	2,140.50			53,294.24	705.76	54,000
State	5,860.80			1.60				81.49	56.11			6,000.00		6,000
North Carolina	49,601.28	3,734.50	3.36	230.13	722.35	701.57	405.11	3,890.26	711.44			60,000.00		60,000
North Dakota	51,419.05	711.64	4.76	335.13	51.06	585.94	901.29	4,355.87	1,599.46	35.80		60,000.00		60,000
Ohio	53,452.64	1,151.46	1,290.22		738.98			1,662.44	213.50			58,509.24	1,490.76	60,000
Oklahoma	43,281.94	1,086.15	68.77	12.86	1,007.25	281.80	1,315.13	9,298.18	2,439.51	1,188.39		59,979.98	20.02	60,000
Oregon	47,786.02	3,394.60	88.51	576.88	18.00	1,336.49	2,510.46	2,316.75	1,972.29			60,000.00		60,000
Pennsylvania	52,836.74	730.40	14.60	48.84	77.38		344.99	4,481.37	1,465.68			60,000.00		60,000
Puerto Rico	33,139.45	2,434.15	31.00				288.70	5,931.57	15,686.77			57,511.64	2,488.36	60,000
Rhode Island	45,907.12	506.85	60.85		37.00	558.55	383.09	11,026.02	1,442.69	27.42		59,949.59	50.41	60,000
South Carolina	46,526.49	608.15	454.10	543.79	979.32	1,411.85	642.60	6,272.10	2,178.81		382.79	60,000.00		60,000
South Dakota	46,312.85	1,981.81	129.79	379.07	439.71	872.16	446.89	4,513.55	4,924.17			60,000.00		60,000
Tennessee	53,785.94	611.12	119.93	31.83	151.79	123.14	823.16	3,474.50	878.59			60,000.00		60,000
Texas	52,112.95	995.35	30.04	298.65	11.90		662.42	3,967.37	1,921.32			60,000.00		60,000
Utah	50,178.45	1,910.86	149.70	53.03	460.00	850.11	597.33	3,221.28	2,534.77	44.47		60,000.00		60,000
Vermont	52,214.96	1,238.91	52.14	80.22	184.76	743.26	1,190.94	2,972.87	644.61	10.04	667.29	60,000.00		60,000
Virginia	52,460.45	617.58	18.62	19.87	1,446.97	1,601.50	592.36	2,504.99	737.66			60,000.00		60,000
Washington	50,830.15	1,906.81	11.76	82.70		805.32	239.22	4,245.68	1,166.11		712.25	60,000.00		60,000
West Virginia	45,609.82	993.53	188.47		1,519.01	174.23	266.01	8,322.93	2,926.00			60,000.00		60,000
Wisconsin	55,705.80	429.50	53.07	7.91	29.26	10.47	64.55	3,694.54	4.90			60,000.00		60,000
Wyoming	49,254.10	2,312.34	69.01	19.59	123.51	253.61	540.10	6,852.39	575.35			60,000.00		60,000
Total	2,466,383.71	65,105.09	6,785.96	5,617.47	22,383.79	25,509.28	32,549.94	252,161.25	97,481.39	17,534.37	5,978.40	2,997,490.65	17,509.35	3,015,000

[1] Extended to Hawaii by act of May 16, 1928; to Alaska by act of Feb. 23, 1929; and to Puerto Rico by act of Mar. 4, 1931.

TABLE 6.—*Expenditures and appropriations under the Bankhead-Jones Act (June 29, 1935) for the year ended June 30, 1944*

Station	Expenditures												Unexpended	Appropriation
	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractual services	Supplies and materials	Equipment	Lands and structures (contractual)	Contributions to retirement	Total expenditures		
Alabama	$56,442.70	$1,591.54	$409.50	$171.20	$877.80	$173.00	$1,333.50	$11,660.65	$9,552.18	$483.05		$82,695.12		$82,695.12
Alaska	1,280.41	38.10						533.93	400.00			2,252.44		2,252.44
Arizona	7,937.30	1,006.75	54.11	156.42	94.06	450.91	326.95	2,150.33	553.41	554.92		13,285.16		13,285.16
Arkansas	43,500.74	1,534.95	55.78	83.73	1,306.37	1,836.58	537.01	7,404.13	5,599.06		$642.13	62,500.48	$1,482.72	63,983.20
California	81,893.64											81,893.64		81,893.64
Colorado	15,034.96	1,187.63	13.22	52.90	523.57	1,076.09	547.23	2,915.97	806.29		273.10	22,430.96		22,430.96
Connecticut:														
State	9,735.78		11.81				5.40	1,091.79	346.63			11,191.41	62.25	11,253.66
Storrs	8,700.02		6.70		12.75	6.30	36.18	2,011.11	225.10			10,998.16	255.50	11,253.66
Delaware	3,981.17	4.85				107.38		1,076.56	20.00			5,189.96		5,189.96
Florida	25,568.30	742.65	52.43		152.84		221.69	5,571.94	2,194.71	277.60		34,782.16		34,782.16
Georgia	50,446.42	909.13	276.12	2.18	391.78	993.64	1,227.48	27,510.15	5,766.02			87,522.92		87,522.92
Hawaii	7,828.87							1,207.53	150.00			9,186.40		9,186.40
Idaho	10,971.63	432.54	20.22	6.90	280.60	25.58	164.78	1,248.32	554.51	514.76		14,219.84		14,219.84
Illinois	57,971.62	1,990.22	151.10	85.11	148.78	77.06	4,538.81	7,834.01	11,181.20	1,352.44	1,256.05	86,586.40	150.12	86,736.52
Indiana	52,602.00	1,038.40	483.93	21.81	131.85		692.10	4,616.05	2,372.47	941.83		62,900.44		62,900.44
Iowa	63,007.49			1.35				976.86	630.00	238.94		64,854.64		64,854.64
Kansas	42,980.66	220.82				20.80	587.26	4,878.34	1,363.08			50,050.96		50,050.96
Kentucky	72,787.89	653.36	144.17	677.78	4.88	1,480.51	122.50	4,485.29	1,176.94			81,533.32		81,533.32
Louisiana	43,625.94	2,575.62	100.52	35.90		356.80	1,210.88	3,876.55	4,720.59			56,502.80		56,502.80
Maine	16,541.54	1,851.11	10.64		65.20	444.15	56.67	1,616.45	106.40			20,692.16		20,692.16
Maryland	22,844.52	657.23	3.25	30.40	372.63	62.00	196.99	4,869.62	1,223.08			30,259.72		30,259.72
Massachusetts	18,669.92							5.00				18,674.92		18,674.92
Michigan	63,679.19	1,038.14	29.05		109.21	232.81	1,307.75	3,688.40	3,482.05			73,566.60		73,566.60
Minnesota	44,503.34	2,030.65	429.41	59.97	60.86	115.65	691.96	7,231.42	1,471.14		674.64	57,269.04		57,269.04
Mississippi	56,399.71	973.48	290.36	256.16	1,471.83	1,502.55	781.37	8,078.88	1,965.06	932.00		72,651.40		72,651.40
Missouri	50,433.64	685.11	168.60	395.30	650.80	1,489.82	618.73	18,112.82	3,138.35	391.41	883.22	76,967.80		76,967.80
Montana	14,103.12		.95	12.72	218.94		59.25	959.75	148.43			15,503.16		15,503.16
Nebraska	31,211.19	583.05	8.05	19.00	207.00	1,115.56	27.47	4,039.01	1,566.27			38,776.60		38,776.60
Nevada	2,515.04	41.37		.71				35.52	89.50		52.50	2,734.64		2,734.64
New Hampshire	7,422.34	470.90	5.04	20.75	98.00	25.40	21.46	220.24	223.27			8,507.40		8,507.40
New Jersey	24,444.07	333.50	6.93		209.00	396.49	31.83	5,461.85	376.65			31,260.32		31,260.32

New Mexico	11,202.77	18.56	191.16	3.60	208.23		322.52	2,342.00	177.80	49.36		14,516.00		14,516.00
New York:														
Cornell	61,968.46	2,190.62	20.93	119.00	871.91	237.54	895.27	10,112.39	7,391.87	1,136.94		84,944.93	85.47	85,030.40
State	6,390.39			61.57		23.19	4.63	858.76	2,109.30			9,447.84		9,447.84
North Carolina	87,143.06	5,656.27	232.01	403.30	866.78	39.75	784.61	7,819.33	3,059.45	81.00		106,085.56		106,085.56
North Dakota	21,048.40	212.60	26.37	45.92	100.58	15.16	168.57	1,662.54	1,395.62			24,675.76		24,675.76
Ohio	73,264.75	1,141.92	356.93		615.17	2,450.00	27.02	13,412.77	1,601.75			92,870.31	847.33	93,717.64
Oklahoma	40,629.48	379.93	615.99	6.86	296.00	385.09	1,074.33	19,068.14	4,999.78	995.24		68,450.84		68,450.84
Oregon	17,234.57	513.95	5.93	24.89	76.00	17.63	228.45	3,513.49	1,115.41	60.00		22,790.32		22,790.32
Pennsylvania	119,286.76	2,278.53	111.72	60.00	57.10	175.14	76.47	9,269.76	1,858.82	2,148.34		135,322.64		135,322.64
Puerto Rico	32,991.92	256.30	48.11		664.99	900.00	83.00	13,819.47	3,163.40	64.50		51,991.69	1,221.55	53,213.24
Rhode Island	2,411.24							37.80				2,449.04		2,449.04
South Carolina	41,908.82	132.88	101.45	186.79	381.76	114.17	252.89	7,750.20	2,867.57	5,602.20	166.23	59,464.96		59,464.96
South Dakota	18,858.98	677.66	90.97	95.25	35.00	21.58	131.45	3,033.57	1,487.98			24,432.44		24,432.44
Tennessee	60,664.57	1,034.88	862.08	42.57	314.47	674.96	490.47	9,962.58	2,872.50	216.96		77,136.04		77,136.04
Texas	124,230.27	3,440.09	29.31	60.32	47.27	89.00	1,346.77	14,659.57	5,402.34	59.82		149,364.76		149,364.76
Utah	9,264.74	834.92	1.99		1.65		64.01	160.02	176.35			10,503.68		10,503.68
Vermont	6,620.65	130.08	11.39	2.73	74.03	284.33	309.14	1,294.90	817.80	641.89	119.45	10,306.39	165.21	10,471.60
Virginia	55,002.15	793.94	36.77	46.30	326.39	1,346.53	1,335.13	9,766.02	1,023.51	1,467.82		71,144.56		71,144.56
Washington	25,477.37	1,310.73		16.25	62.50	4.00	197.63	5,191.95	606.21		388.00	33,254.64		33,254.64
West Virginia	43,675.00	2,202.17	113.10	9.15	234.46	773.82	379.88	5,762.79	2,670.62	38.17		55,859.16		55,859.16
Wisconsin	57,616.43	259.56	48.98			71.60	1.30	2,227.01				60,224.88		60,224.88
Wyoming	5,772.02	564.33					190.04	192.13	41.00			6,759.52		6,759.52
Total	1,931,727.96	46,621.02	5,637.08	3,274.79	12,623.04	19,612.57	23,708.83	287,285.66	106,241.47	18,249.19	4,455.32	2,459,436.93	4,270.15	2,463,707.08

TABLE 7.—*Expenditures from non-Federal funds for the year ended June 30, 1944*

Station	Personal services	Travel	Transportation of things	Communication service	Rents and utility services	Printing and binding	Other contractural services	Supplies and materials	Equipment	Lands and structures (contractural)	Contributions to retirement	Total
Alabama	$160,330.89	$8,645.63	$3,037.44	$1,944.59	$4,148.97	$137.93	$17,134.92	$81,289.85	$29,229.84	$8,596.98	----------	$314,497.04
Alaska	12,066.42	573.69	1,087.48	398.37	1,208.55	71.00	1,643.63	4,053.47	2,801.07	1,206.78	----------	25,110.46
Arizona	94,922.65	2,758.94	609.78	1,835.36	3,302.06	2,202.49	7,323.34	15,401.21	9,902.64	----------	----------	138,258.47
Arkansas	101,486.11	11,146.37	242.63	2,061.23	4,200.46	177.64	4,004.87	41,893.19	10,232.07	18,667.58	$2,169.85	196,282.00
California	1,079,214.36	34,265.29	3,829.89	16,532.36	27,213.16	44,948.63	21,102.79	101,334.60	30,335.61	----------	----------	1,358,776.69
Colorado	96,879.27	3,368.18	1,350.65	1,786.01	9,638.16	3,513.16	6,884.71	65,342.54	9,319.60	18,131.96	714.65	216,928.89
Connecticut:												
State	126,564.04	1,611.09	107.11	1,429.68	3,484.66	62.17	1,929.46	12,723.18	2,928.89	----------	----------	150,840.28
Storrs	51,628.82	958.07	145.01	263.86	7.50	117.84	691.52	9,632.28	3,338.82	----------	----------	~~71,283.72~~ 66,783
Delaware	41,199.83	1,973.44	460.48	1,065.35	2,614.77	192.84	1,768.19	37,871.72	4,983.83	37,729.16	----------	~~669,650.61~~ 629,85
Florida	451,382.31	16,733.96	3,189.96	4,041.76	12,835.95	3,910.11	15,126.58	118,645.36	29,371.82	18,583.91	----------	673,821.72
Georgia	71,559.64	1,201.79	1,246.70	1,037.40	6,115.01	1,685.08	6,284.60	19,040.84	5,983.40	----------	----------	114,154.46
Hawaii	116,989.38	1,778.79	164.97	1,122.36	4,286.14	3.98	7,270.40	17,146.65	872.01	----------	----------	149,634.68
Idaho	32,016.33	4,000.00	900.00	700.00	2,000.00	1,900.00	2,000.00	20,000.00	2,000.00	3,500.00	----------	69,016.33
Illinois	408,763.19	30,000.00	----------	11,000.00	----------	21,000.00	----------	124,238.74	24,638.24	----------	----------	619,640.17
Indiana	341,911.42	14,905.51	3,697.44	6,401.32	9,923.81	10,036.06	39,273.96	200,777.23	44,911.49	4,013.88	3,100.00	678,952.12
Iowa	259,834.29	15,629.19	2,117.16	3,359.52	----------	11,456.70	----------	146,999.44	22,800.88	----------	----------	462,197.18
Kansas	173,499.74	4,944.38	2,048.99	2,314.42	7,113.50	973.61	12,361.38	55,878.56	19,260.04	480.00	----------	278,874.62
Kentucky	210,968.02	11,607.80	1,303.78	1,661.58	10,756.51	15,440.53	13,402.57	48,603.44	9,785.44	----------	----------	323,529.67
Louisiana	198,991.72	14,860.03	1,324.04	2,731.27	5,918.98	746.81	7,935.47	58,183.91	39,979.08	----------	----------	330,671.31
Maine	100,238.44	6,220.41	2,612.09	1,033.85	8,143.71	4,764.97	2,944.92	17,286.40	3,771.55	743.94	----------	147,760.28
Maryland	78,105.98	2,468.83	979.06	892.39	1,149.33	967.71	4,761.54	61,823.48	12,599.94	4,925.01	8,840.00	177,513.27
Massachusetts	145,598.42	2,118.53	366.05	1,216.71	531.38	1,274.60	596.86	13,483.31	6,162.67	380.30	----------	171,728.83
Michigan	203,219.08	8,689.39	583.72	892.66	3,245.30	12,998.00	8,016.81	36,564.65	7,703.54	360.82	----------	282,273.97
Minnesota	329,419.77	6,843.77	2,436.09	3,904.65	6,942.73	5,270.85	31,371.49	88,599.25	15,738.31	1,319.14	----------	491,846.05
Mississippi	168,036.45	5,686.12	1,761.63	1,785.28	4,310.46	8,455.27	10,273.25	28,436.45	20,286.55	17,082.77	----------	266,114.23
Missouri	83,845.66	4,639.55	2,828.49	2,448.15	4,663.53	8,026.66	5,615.01	57,935.78	3,618.91	4,007.95	----------	177,629.69
Montana	107,339.51	3,355.03	1,863.76	1,001.29	6,943.76	1,067.85	8,641.22	39,011.27	12,500.70	22,069.74	----------	203,794.14
Nebraska	58,177.13	4,696.34	2,014.06	1,330.82	7,733.27	3,226.65	11,331.27	132,220.45	29,037.28	3,410.77	----------	253,178.04
Nevada	755.56	397.26	18.74	112.05	478.34	468.42	813.60	784.20	705.23	95.05	----------	4,628.45
New Hampshire	7,112.96	147.86	7.78	3.30	----------	----------	166.84	723.08	5,681.23	----------	----------	13,843.05
New Jersey	414,148.32	8,408.60	324.20	8,188.03	19,198.46	8,848.99	14,114.97	80,884.27	1,284.28	----------	599.23	555,999.35
New Mexico	26,705.39	254.76	634.02	199.24	1,771.10	463.67	6,374.94	12,396.50	989.40	92.53	----------	49,881.55
New York:												
Cornell	619,174.43	15,325.65	2,881.61	8,535.13	66,177.23	7,250.61	14,199.39	116,378.08	19,363.84	----------	----------	869,285.97
State	321,135.29	6,776.29	556.61	3,102.06	7,158.37	5,304.06	8,808.99	38,353.45	4,932.52	----------	----------	396,127.64

North Carolina	146,345.85	10,634.48	728.75	2,154.62	3,627.73	2,945.61	7,460.54	38,639.19	[illegible]	[illegible].92		233,013.40
North Dakota	58,675.70	2,980.61	227.22	769.19	20,728.94	1,561.44	8,269.90	26,883.[illegible]	[illegible]	3,074.30		130,223.46
Ohio	519,675.98	9,573.40	3,380.67	3,873.65	12,172.52	24,006.65	13,709.46	133,88[illegible]	[illegible],302.83			760,827.78
Oklahoma	196,860.06	6,517.82	1,404.58	1,648.76	5,895.30	2,688.94	6,620.00	73.[illegible]5	18,188.00	21,880.18		334,854.00
Oregon	295,481.84	11,177.40	1,901.02	3,737.02	12,268.09	3,196.44	15,983.61	55,731.76	19,982.33	2,556.88		420,016.39
Pennsylvania	199,497.52	8,255.14		1,215.76	3,091.85	2,216.91	28,347.42	43,010.27	24,862.81	3,256.62		313,754.30
Puerto Rico	169,139.53	3,777.58	199.15	1,127.38	6,764.28	3,727.81	453.00	25,994.81	5,269.46			216,453.00
Rhode Island	9,295.93	169.06	96.42	113.96	183.80	120.15	155.35	6,268.66	1,950.18	437.25		18,790.76
South Carolina	147,035.37	3,172.93	6,141.35	1,833.23	6,100.66	711.98	29,191.50	134,770.73	26,444.27	12,351.78	818.84	368,572.64
South Dakota	51,953.50	1,696.46	203.04	125.17	910.02	450.26	703.63	27,622.37	5,979.87	71.56		89,715.88
Tennessee	78,485.27	1,161.14	2,266.79	877.32	1,540.67	919.68	12,993.54	48,326.41	12,447.49	21,461.20		180,479.51
Texas	428,351.31	6,771.50	2,114.04	3,326.23	14,033.31	3,893.66	57,315.06	134,541.05	67,721.89	36,679.49	19,794.10	774,541.64
Utah	46,124.22	3,946.14	503.45	1,258.82	4,067.36	2,070.91	2,744.73	15,189.12	15,117.30	6,624.24	1,580.88	99,227.17
Vermont	16,414.52	910.65	27.87	148.20	163.52	310.74	1,541.12	1,290.26	201.10	2,246.77	106.24	23,360.99
Virginia	104,913.35	4,575.67	836.49	1,460.19	4,554.43	3,766.52	4,426.94	13,993.84	10,255.16	2,929.72		151,712.31
Washington	241,501.46	14,612.60	1,419.15	2,112.65	5,720.98	3,813.64	7,266.43	62,134.43	10,995.27	1,658.29	2,914.50	354,149.40
West Virginia	63,836.56	4,136.36	1,221.96	1,081.54	3,495.58	1,890.38	1,532.49	34,548.07	13,856.00	16,121.32		141,720.26
Wisconsin	481,806.00	13,010.00	956.00	1,207.00	6,135.00	4,488.00	8,894.00	122,535.00	27,659.00			666,690.00
Wyoming	34,591.63	1,826.27	1,084.90	844.45	2,112.22	21.75	1,398.47	32,180.89	7,250.73			81,311.31
Total	9,983,206.42	365,895.75	71,444.27	125,247.19	366,781.42	249,766.37	503,176.68	2,932,630.62	778,843.73	301,217.39	40,638.29	15,718,848.13

TABLE 8.—*Disbursements from the U. S. Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the Hatch Act (Mar. 2, 1887), Adams Act (Mar. 16, 1906), Purnell Act (Feb. 24, 1925), Bankhead-Jones Act (June 29, 1935), and supplementary acts*

State or Territory	Hatch Act 1888–1944	Adams Act 1906–44	Purnell Act 1926–44	Bankhead-Jones Act 1936–44
Alabama	$854,199.34	$551,059.10	$1,039,903.19	$609,876.51
Alaska	195,000.00	52,500.00	25,000.00	16,389.06
Arizona	819,467.73	554,995.61	1,039,986.80	94,204.18
Arkansas	853,127.12	554,900.00	1,039,548.26	471,876.10
California	855,000.00	554,926.84	1,040,000.00	534,176.99
Colorado	854,718.82	553,638.93	1,040,000.00	165,428.33
Connecticut	854,307.92	555,000.00	1,037,727.33	156,861.69
Dakota Territory	56,250.00			
Delaware	853,258.28	550,062.10	1,033,139.91	37,430.89
Florida	854,966.06	554,996.06	1,036,523.74	239,103.65
Georgia	850,593.43	542,092.87	1,040,000.00	645,481.54
Hawaii	224,919.17	177,720.02	267,500.00	67,749.70
Idaho	779,824.13	550,842.22	1,040,000.00	102,678.22
Illinois	852,184.56	554,716.01	1,033,585.84	634,268.02
Indiana	854,901.19	550,000.00	1,040,000.00	460,875.23
Iowa	855,000.00	555,000.00	1,037,965.17	478,302.97
Kansas	854,995.00	555,000.00	1,040,000.00	369,125.83
Kentucky	854,996.57	555,000.00	1,040,000.00	589,953.88
Louisiana	855,000.00	555,000.00	1,040,000.00	410,717.20
Maine	854,999.62	555,000.00	1,040,000.00	152,604.68
Maryland	854,967.40	554,236.48	1,040,000.00	215,687.51
Massachusetts	854,617.70	555,000.00	1,039,356.82	135,571.89
Michigan	854,676.10	551,341.60	1,039,196.59	513,684.10
Minnesota	854,917.78	554,345.74	1,040,000.00	420,296.79
Mississippi	855,000.00	555,000.00	1,040,000.00	535,804.08
Missouri	850,097.24	554,999.90	1,040,000.00	567,044.84
Montana	765,000.00	552,417.04	1,040,000.00	114,335.81
Nebraska	854,932.16	555,000.00	1,039,995.00	285,977.42
Nevada	853,331.08	551,145.10	1,040,000.00	18,969.22
New Hampshire	854,250.00	555,000.00	1,040,000.00	62,084.95
New Jersey	854,959.97	554,392.06	1,040,000.00	227,331.51
New Mexico	819,509.05	555,000.00	1,040,000.00	103,752.38
New York	854,757.54	554,021.41	1,039,289.62	676,303.12
North Carolina	855,000.00	555,000.00	1,040,000.00	767,254.18
North Dakota	811,491.45	554,589.62	1,039,737.21	181,893.13
Ohio	855,000.00	550,020.68	1,032,893.58	685,998.55
Oklahoma	786,919.88	542,842.65	1,039,907.72	504,316.56
Oregon	840,156.64	550,000.00	1,040,000.00	156,640.09
Pennsylvania	854,967.43	554,995.41	1,040,000.00	995,234.57
Puerto Rico	149,638.71	138,387.23	158,401.84	362,312.84
Rhode Island	854,788.05	549,345.53	1,038,882.18	17,078.93
South Carolina	854,541.37	553,360.12	1,040,000.00	438,554.08
South Dakota	798,250.00	550,000.00	1,040,000.00	180,189.24
Tennessee	855,000.00	555,000.00	1,040,000.00	558,587.60
Texas	855,000.00	552,592.26	1,040,000.00	1,101,565.10
Utah	820,000.00	554,821.94	1,040,000.00	77,464.64
Vermont	854,072.14	550,660.96	1,038,798.56	76,137.79
Virginia	853,766.58	553,544.94	1,039,974.86	517,589.26
Washington	793,414.48	551,080.11	1,040,000.00	228,895.20
West Virginia	854,804.16	551,263.82	1,039,942.89	403,011.28
Wisconsin	855,000.00	555,000.00	1,040,000.00	444,157.81
Wyoming	810,000.00	553,856.59	1,040,000.00	49,851.46
Total	41,080,535.85	26,910,704.95	50,337,257.11	17,860,680.60

ADDRESS LIST OF AGRICULTURAL EXPERIMENT STATIONS

ALABAMA.—*Auburn,* M. J. Funchess, Director.
ALASKA.—*College,* L. T. Oldroyd, Director.
ARIZONA.—*Tucson,* P. S. Burgess, Director.
ARKANSAS.—*Fayetteville,* W. R. Horlacher, Director.
CALIFORNIA.—*Berkeley 4,* C. B. Hutchison, Director.
COLORADO.—*Fort Collins,* H. J. Henney, Director.
CONNECTICUT.—*New Haven 4,* W. L. Slate, Director; *Storrs,* W. L. Slate, Acting Director.
DELAWARE.—*Newark,* G. L. Schuster, Director.
FLORIDA.—*Gainesville,* Harold Mowry, Director.
GEORGIA.—*Experiment,* H. P. Stuckey, Director.
HAWAII.—*Honolulu 10,* J. H. Beaumont, Director.
IDAHO.—*Moscow,* E. J. Iddings, Director.
ILLINOIS.—*Urbana,* H. P. Rusk, Director.
INDIANA.—*La Fayette,* H. J. Reed, Director.
IOWA.—*Ames,* R. E. Buchanan, Director.
KANSAS.—*Manhattan,* L. E. Call, Director.
KENTUCKY.—*Lexington 29,* T. P. Cooper, Director.
LOUISIANA.—*University Station, Baton Rouge 3,* W. G. Taggart, Director.
MAINE.—*Orono,* Fred Griffee, Director.
MARYLAND.—*College Park,* W. B. Kemp, Acting Director.
MASSACHUSETTS.—*Amherst,* F. J. Sievers, Director.
MICIHIGAN.—*East Lansing,* V. R. Gardner, Director.
MINNESOTA.—*University Farm, St. Paul 8,* C. H. Bailey, Director.
MISSISSIPPI.—*State College,* Clarence Dorman, Director.
MISSOURI.—*Columbia,* M. F. Miller, Director.
MONTANA.—*Bozeman,* Clyde McKee, Director.
NEBRASKA.—*Lincoln 1,* W. W. Burr, Director.
NEVADA.—*Reno,* S. B. Doten, Director.
NEW HAMPSHIRE.—*Durham,* M. G. Eastman, Director.
NEW JERSEY.—*New Brunswick,* W. H. Martin, Director.
NEW MEXICO.—*State College,* Fabian Garcia, Director.
NEW YORK.—*Geneva* (State Station), A. J. Heinicke, Director; *Ithaca* (Cornell Station), C. E. F. Guterman, Director.
NORTH CAROLINA.—*State College Station, Raleigh,* L. D. Baver, Director.
NORTH DAKOTA.—*State College Station, Fargo,* H. L. Walster, Director.
OHIO.—*Wooster,* Edmund Secrest, Director.
OKLAHOMA.—*Stillwater,* W. L. Blizzard, Director.
OREGON.—*Corvallis,* W. A. Schoenfeld, Director.
PENNSYLVANIA.—*State College,* F. F. Lininger, Director.
PUERTO RICO.—*Mayaguez* (Federal Station), K. A. Bartlett, Director; *Rio Piedras* (University Station), Arturo Roque, Director.
RHODE ISLAND.—*Kingston,* M. H. Campbell, Director.
SOUTH CAROLINA.—*Clemson,* H. P. Cooper, Director.
SOUTH DAKOTA.—*Brookings,* I. B. Johnson, Director.
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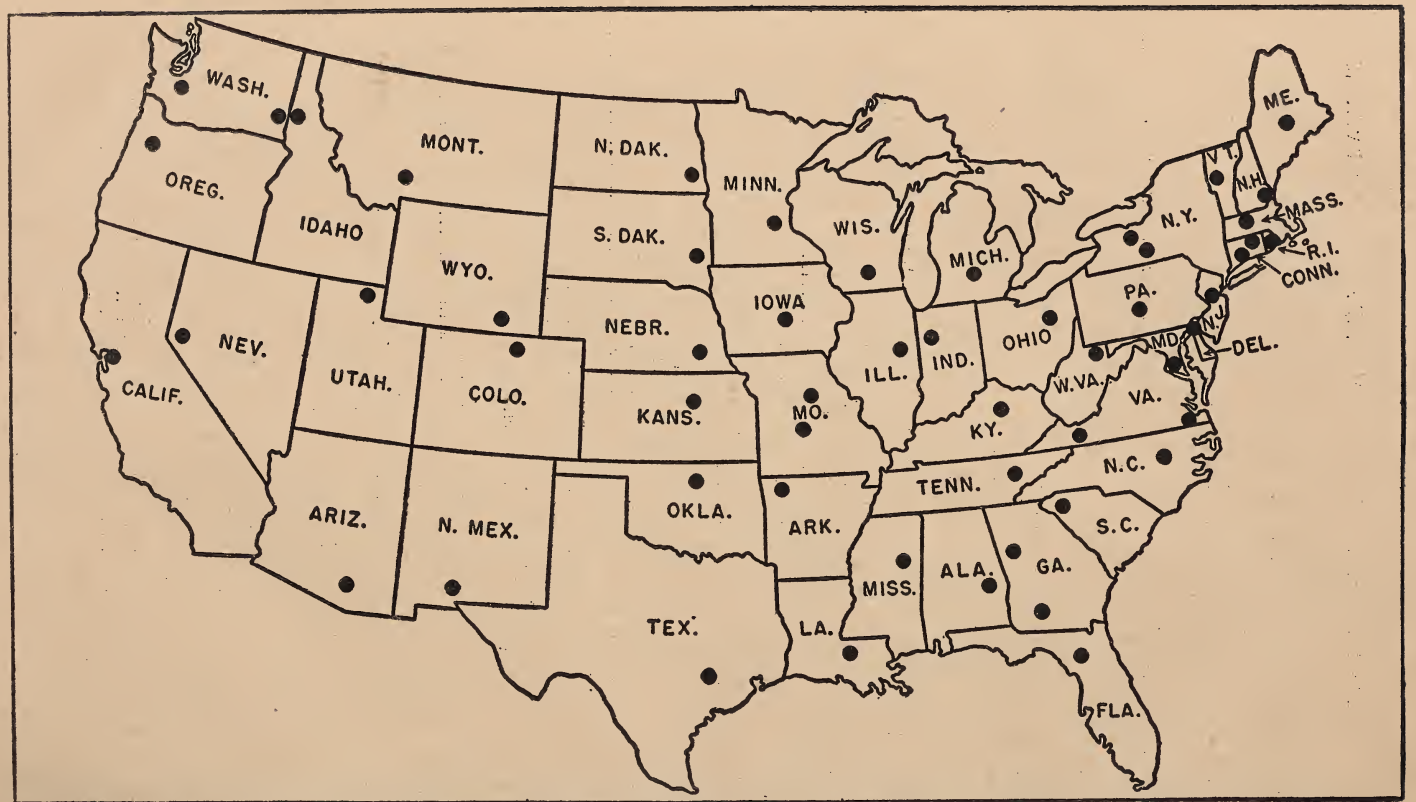
TEXAS.—*College Station,* A. B. Conner, Director.
UTAH.—*Logan,* R. H. Walker, Director.
VERMONT.—*Burlington,* J. E. Carrigan, Director.
VIRGINIA.—*Blacksburg,* A. W. Drinkard, Jr., Director.
WASHINGTON.—*Pullman,* E. C. Johnson, Director.
WEST VIRGINIA.—*Morgantown,* C. R. Orton, Director.
WISCONSIN.—*Madison 6,* E. B. Fred, Director.
WYOMING.—*Laramine,* J. A. Hill, Director.

NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.



HEADQUARTERS OF STATE AGRICULTURAL EXPERIMENT STATIONS